NOTICE

All drawings located at the end of the document.

97-RF-06315
Rev. 2

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Corrective Action Management Unit Interim Measure/Interim Remedial Action Decision Document and Application Support Document for Bulk Storage at the Rocky Flats Environmental Technology Site

DRAFT

June 1997

Environmental Restoration
Rocky Flats Environmental Technology Site

96-RF-06315
RF/ER-95-0105.UN, Rev. 2

Draft Corrective Action Management Unit Interim Measure/Interim Remedial Action Decision Document and Application Support Document for Bulk Storage at Rocky Flats Environmental Technology Site

Rocky Mountain Remediation Services, L.L.C.

February 1997

Revision 1

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ABBREVIATIONS AND ACRONYMS

AEC	United States Atomic Energy Commission
ALARA	As Low As Reasonably Achievable
Am	Americium
APEN	Air Pollution Emission Notice
BMP	Best Management Practices
CAB	Citizens Advisory Board
CAMU	Corrective Action Management Unit
CCR	Code of Colorado Regulations
CDPHE	Colorado Department of Public Health and Environment
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CHWA	Colorado Hazardous Waste Act
cm/sec	centimeters per second
cy	cubic yards
Decision Document	Interim Measure/Interim Remedial Action Decision Document
D&D	Deactivation and Decommissioning
DOE	United States Department of Energy
DOT	United States Department of Transportation
ER	Environmental Restoration
ERDA	Energy Research and Development Administration
ft	feet or foot
FY	Fiscal Year
PPE	Personal Protective Equipment
HW	Hazardous Waste
IA	Industrial Area
IA-East	Industrial Area-East
IA-West	Industrial Area-West
IDM	Investigation-Derived Material
IHSS	Individual Hazardous Substance Site
IM/IRA	Interim Measure/Interim Remedial Action
in.	inch or inches
ITS	Interceptor Trench System
LDR	Land Disposal Restrictions
LLW	Low-Level Waste
LLMW	Low-Level Mixed Waste
nCi/g	nanocuries per gram
NCP	National Contingency Plan
NEPA	National Environmental Policy Act
NPDES	National Pollutant Discharge Elimination System

NSL	New Sanitary Landfill
NTS	Nevada Test Site
OU	Operable Unit
QA/QC	Quality Assurance/Quality Control
QAT	Quality Action Team
PA	Protected Area
PAC	Potential Areas Of Concern
PCB	Polychlorinated Biphenyls
PCE	Tetrachloroethene
pCi	Picocuries
PPRG	Programmatic Preliminary Remediation Goals
Pu	Plutonium
RCRA	Resource Conservation and Recovery Act
RFCA	Rocky Flats Cleanup Agreement
RWSF	Remediation Waste Storage Facility
SE Quad	Southeast Quadrant
Site	Rocky Flats Environmental Technology Site
Site Vision	Rocky Flats Conceptual Vision
SW Quad	Southwest Quadrant
TCE	Trichloroethene
TRU	Transuranic
TSCA	Toxic Substance Control Act
U.S.	United States
VOC	Volatile Organic Compounds
WAC	Waste Acceptance Criteria
WIPP	Waste Isolation Pilot Plant

EXECUTIVE SUMMARY

The Department of Energy is requesting that the State of Colorado designate a Corrective Action Management Unit (CAMU) for bulk storage of remediation wastes at the Rocky Flats Environmental Technology Site (RFETS). The storage unit within the CAMU area would be known as the Remediation Waste Storage Facility (RWSF). This CAMU designation is being requested as an option to facilitate risk reduction activities in support of site closure at RFETS. This designation will support a final remedy of source removal coupled with offsite disposal. This designation would serve as a contingency in the event assumptions in the Ten Year Plan (DOE 1996a) regarding offsite disposal of remediation waste as it is generated prove to be invalid and onsite storage capacity becomes necessary to facilitate risk reduction. The CAMU designation would ensure that waste management logistics associated with the timing of waste generation, onsite storage, and offsite disposal capabilities would not impact schedules for risk reduction at RFETS.

The lack of complete site characterization data for RFETS environmental media (especially in the Industrial Area) and Deactivation and Decommissioning (D&D) waste results in a wide range of waste volume estimates. Current volume estimates for remediation wastes are approximately 94,000 cubic meters but have ranged up to over 300,000 cubic meters. This high degree of uncertainty in waste volume estimates and future offsite disposal resources underscores a need for a flexible waste management strategy in order to achieve cost-effective and timely site closure. The desired and most cost effective alternative is immediate offsite disposal of remediation wastes as they are generated. However, in the event this cannot occur for the reasons stated above, the bulk storage CAMU allows risk reduction to continue.

An additional CAMU designation request for a containerized storage facility will follow this submittal. A combination of both bulk and containerized storage contingencies forms an overall spectrum of waste management options that ensures, in the event that actual waste volumes exceed estimates in the Ten Year Plan, or offsite disposal capabilities limit waste shipment, risk reduction activities could proceed and site closure could continue in as cost effective manner as possible.

The CAMU designation request is presented in the form of this Interim Measures/Interim Remedial Action (IM/IRA) Decision Document and Application Support Document. The CAMU-designated RWSF would support a cost-effective, flexible, and achievable remediation waste management contingency for onsite storage at RFETS. The overall objective of this document is to support a State CAMU designation by providing the rationale and a proposed alternative that support the goals of the Rocky Flats Cleanup Agreement (RFCA) (DOE 1996b) and the Ten Year Plan. The CAMU would support the RFCA goal (Preamble, B2 [a]) of initially controlling sources of contamination as a priority over off-site shipment.

Only remediation wastes would be managed in this facility. Remediation waste types would include contaminated soil collected from cleanup actions; treated and untreated sludge and sediments; treatment by-products from groundwater, surface water, and/or soil remedial actions; investigation derived materials (i.e. drill cuttings) from past and future characterization activities; and decontamination waste and building debris which has been characterized as hazardous, low-level radioactive, or low-level mixed waste. It is the intent of DOE to request a CAMU for storage only. As described in Paragraph 80 of RFCA, a finding of fact by CDPHE as to whether the proposed facility also meets the requirements for a disposal facility, is not requested. It is intended that this facility would be clean closed, including removal of remediation waste and decontamination of the structure, in accordance with cleanup levels established in RFCA.

This CAMU decision document details how the CAMU-designated RWSF supports risk reduction and eventual site closure in the following ways:

- The CAMU shall facilitate the implementation of reliable, effective, protective, and cost effective remedies. This would be implemented in accordance with the requirements of RFCA and serve as a contingency to the strategy detailed in the Ten Year Plan.

- This CAMU designation would support a flexible waste management strategy that emphasizes offsite remediation waste disposal, as described in the Ten Year Plan, while recognizing the uncertainties associated with current remediation waste volume estimates and future disposal capabilities that may impact the ability to perform timely risk reduction.

- The CAMU would focus resources on immediate risk reduction by deferring treatment costs not necessary to protect human health or the environment, and would focus resources on actual cleanup and source removal.

- The CAMU may allow DOE to achieve economies of scale, in terms of unit costs, making treatment and eventual disposal less costly and more practical by consolidating remediation waste and addressing long term liability and safety issues.

This decision document identifies applicable regulatory criteria for CAMU designation by the CDPHE and provides information on how the RWSF would meet these criteria. In addition, this document identifies the other appropriate criteria supporting the selection of the CAMU location and the conceptual design. National Environmental Policy Act (NEPA) values were also addressed within this selection process. Preliminary waste acceptance criteria, closure requirements, and a timeline are also included in this document.

Based upon the screening and comparison of alternatives, a concrete-lined cell design (which would be constructed over a double-lined leachate detection and collection system) was proposed for a bulk storage CAMU. This facility would be located in the eastern portion of the Protective Area near the solar evaporation ponds formerly known as Operable Unit 4 (Figure ES-1). This CAMU would incorporate design features compliant with the Resource Conservation and Recovery Act (RCRA) Subtitle "C" requirements, as stated in the Code of Colorado Regulations (CCR) 6 CCR 1007-3, Part 264 Subpart N and required in Paragraph 80 of RFCA. An operational cover would limit exposure of waste to the environment. Each cell would consist of separate internal modules, the final configuration being dependent upon waste management needs at the time of operation. The modules would each store up to 33,000 cubic yards of bulk remediation waste for a total of 100,000 cubic yards per cell. The facility would be expandable to up to three cells, as necessary, for a total facility capacity of 300,000 cubic yards. The operational time frame proposed is 25 years after CAMU designation. Actual operations are anticipated to be much shorter in duration. The time frame for CAMU implementation is dependent upon the factors described above as well as future funding scenarios as identified in the Ten Year Plan.

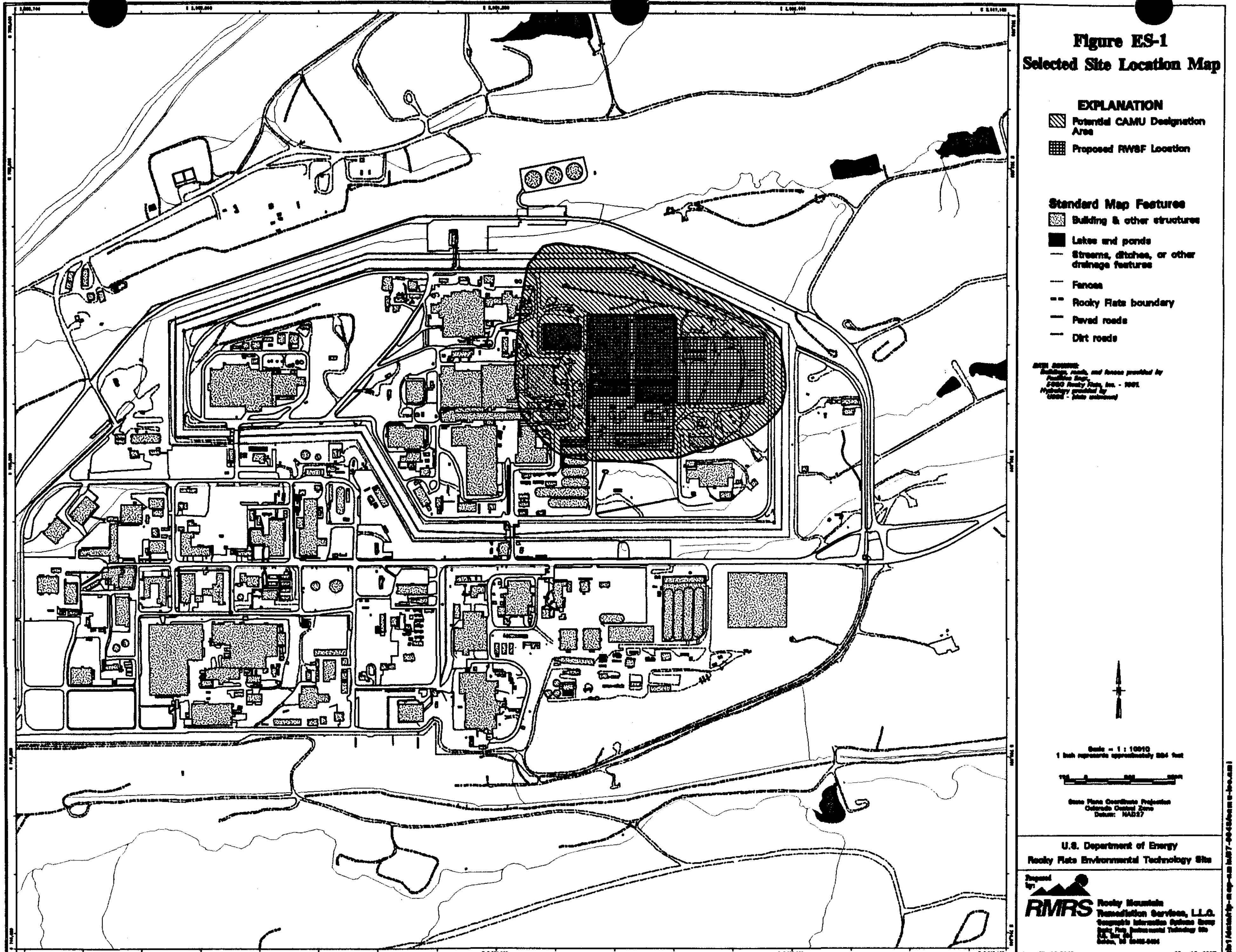


Figure ES-1
Selected Site Location Map

1.0 INTRODUCTION

The document serves as the application for designation of the proposed Remediation Waste Storage Facility (RWSF) as a Resource Conservation and Recovery Act (RCRA) Corrective Action management Unit (CAMU). This Decision Document provides the United States Department of Energy's (DOE) technical justification and decision-making process for the option of siting and construction of a RWSF for storage of remediation waste, including Deactivation and Decommissioning (D&D) wastes, at the Rocky Flats Environmental Technology Site (RFETS) (see Figure 1-1). The CAMU designation is available as a regulatory alternative to facilitate the implementation of reliable, effective, protective and cost-effective remedies.

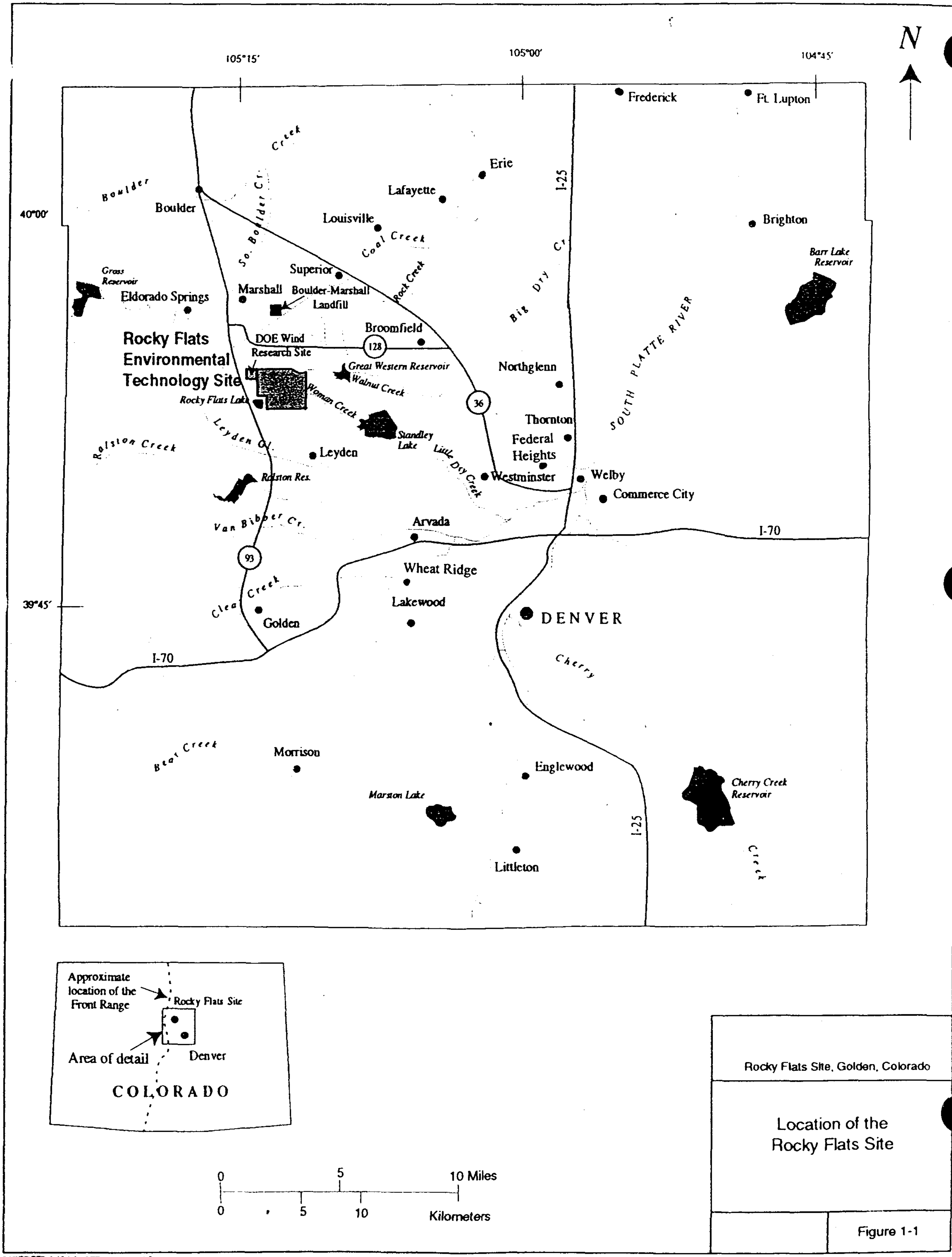
The strategy for site closure is detailed in the DOE 10 Year Plan (Ten Year Plan) for RFETS (DOE 1996a). This plan assumes that closure is linked to a policy of aggressive offsite shipment of waste as it is generated. Assumptions in the plan that support schedules for both environmental restoration (ER) and building D&D include the availability of offsite facilities to accept the waste in a timely manner, onsite storage capabilities to facilitate shipment, and waste volume estimates. Uncertainties are associated with the current waste volume estimates due to a lack of thorough ER site and building characterization data. In addition, there are uncertainties associated with the availability of offsite disposal resources that may impact waste shipments. Changes from the assumptions described above could significantly impact the DOE's ability to perform timely risk reduction and eventual closure of RFETS. The CAMU designation for bulk remediation waste storage is necessary as a contingency to achieve the cleanup goals This CAMU designation is requested to ensure that the ability to perform risk reduction activities would not be impacted in the event assumptions that drive the schedules for site closure are not valid.

The type of wastes to be managed at RFETS would be remediation wastes consisting of low-level, low-level mixed, and hazardous ER wastes and D&D waste, which is amenable to bulk handling and storage. Low-level waste refers to waste forms that are not high-level waste, spent nuclear fuels, by-product material, or transuranic wastes and which have less than 100 nCi/g of transuranic radioactivity.

Within this Decision Document is the information necessary for the Colorado Department of Public Health and Environment (CDPHE) to designate a CAMU with the RWSF being the facility used for storage. By having a CAMU designation, the DOE can meet the waste management objectives consistent with the recently signed Rocky Flats Cleanup Agreement (RFCA), July 19, 1996 (DOE 1996b). The importance of the CAMU option was also recognized by the State of Colorado Hazardous Waste Commission when it stated in the introduction of the CAMU Statement of Basis that a CAMU "can facilitate corrective actions" (i.e., environmental cleanups at facilities like RFETS). The approval process for a CAMU is envisioned as a three-step process as follows:

1. IM/IRA concept validation including CAMU designation. Per Paragraph 109 of RFCA, approval of this IM/IRA will constitute CAMU designation.

2. Design/Preparation for Construction. Consisting of Title II design, Groundwater Monitoring Plan, Construction Quality Assurance Plan, Test Fill Plan, Closure Plan, and other plans as appropriate to support the design phase.



Rocky Flats Site, Golden, Colorado

Location of the Rocky Flats Site

Figure 1-1

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3. Construction/Preparation for Operations. Including Inspection, Operation, Waste Acceptance, Emergency and Security Plans

All phases would have State and public input and final State approval. As described in Paragraph 109 of RFCA (Appendix A), approval of this decision document will constitute designation of a CAMU by the State of Colorado.

The CAMU area being sought through this Decision Document would be located within the eastern portion of the Protected Area (PA) of RFETS (see Section 7.1). Within this CAMU area, an above-grade concrete-lined storage cell serving as the RWSF would be constructed to store remediation waste primarily in bulk form. The CAMU would consist of up to three concrete-lined cells, each designed to hold up to 100,000 cubic yards (cu yd) of remediation waste for a total of 300,000 cu yd; the actual capacity, however, could be adjusted because of the conceptual modular design. Each cell would consist of separate internal modules. The final configuration would be dependent on the waste management needs at the time of operation. The modules would each store up to 33,000 cu yd of bulk remediation waste for a total of 100,000 cu yd per cell. Furthermore, this RWSF would incorporate retrieval and monitoring aspects.

It is the intent of the DOE to request a CAMU for storage only, and that all waste would be removed from the RWSF prior to closure. As described in Paragraph 80 of RFCA, a finding of fact by CDPHE as to whether the proposed facility also meets the requirements for a disposal facility, is not requested

1.1 DECISION DOCUMENT ORGANIZATION

This Decision Document is structured to provide the information required to support the technical justification of the CAMU and to provide sufficient information for the CDPHE to designate the CAMU. This document also provides the decision-making process used by the DOE to arrive at the conclusion that a RWSF is required as a contingency to meet RFCA and Site Vision objectives.

This document is divided into 9 sections with 8 appendices and is structured as the following sequential decision process:

- This document identifies a need for a CAMU designation for waste storage.
- This document identifies the requirements for a bulk storage RWSF CAMU at RFETS.
- This document describes the RWSF alternatives analysis process, the recommended RWSF alternative, and how the proposed alternative meets the requirements previously identified.

The document also discusses facility-specific issues including:

- Waste characteristics and source volume estimates
- Conceptual waste acceptance criteria (WAC)
- General design requirements
- General monitoring requirements

With the final selection of the concrete-lined waste cell, this document addresses 6-CCR-1007-3 264.552 (c). (Appendix A). This is followed by an identification of the requirements that a CAMU would need to meet. This, in turn, is followed by an evaluation and recommendation of the specific type of CAMU needed to meet the requirements identified.

This Introduction presents the objectives of the Decision Document, the role of the CAMU and RWSF at RFETS, and a description and history of RFETS. Section 2 provides a point-by-point discussion of how the proposed CAMU and RWSF meet each of the seven decision criteria under RCRA for the CAMU. It is these criteria which would be used by the CDPHE to make a CAMU determination. Waste characteristics of the material to be stored in the CAMU are presented in Section 3.0.

The development of alternative actions and the selection of the preferred alternative for the management of low-level and low-level mixed, and hazardous remediation waste are presented in Section 4.0 through Section 6.0. Section 4.0 addresses substantive criteria as described in paragraphs 80 and 109 of RFCA and regulatory requirements spelled out in 6 CCR 1007-3, Subpart S, Part 264, to obtain CDPHE approval for a CAMU (Appendix A). Section 5.0 describes how the final alternatives for a CAMU were developed. It includes a description of the screening methodology and the description and results of the two screening phases: the facility siting study and the facility design screen (Appendices C, D, and E). Section 6.0 describes the final comparison of alternatives and the rational for the selected remedy. Section 7.0 is a detailed discussion of the selected remedy (i.e., the concrete-lined waste cell located in the eastern portion of the Protected Area). Appendix B support section 7.0. These details include a risk evaluation, waste acceptance criteria, facility operations, National Environmental Policy Act (NEPA) values, and a summary of the value engineering study. The schedule for the design and construction of the RWSF is presented in Section 8.0, and references are included in Section 9.0.

1.2 CAMU DECISION DOCUMENT SCOPE AND OBJECTIVES

The following two sections discuss the scope and objectives for this Decision Document.

1.2.1 Scope Description

All alternatives, including the "No Action" alternative, assume that the assumption in the Ten Year Plan of offsite waste disposal as waste is generated is no longer valid. The alternatives are evaluated in terms of a contingency supporting risk reduction goals while recognizing that offsite disposal, waste volume, and/or onsite storage assumptions have been impacted and no longer support the Ten Year Plan risk reduction/site closure schedules. In discussing the need for a storage facility, this document develops and evaluates the various alternatives available to manage remediation waste, including offsite disposal and various long-term storage.

Included as part of the decision-making process are two screening phases used to narrow the various alternatives:

- A siting study to select a suitable location for onsite options
- A facility design alternatives analysis to evaluate design alternatives for onsite storage

From the possible locations identified in the siting study, the best location was selected and then used as a basis for the facility design screen. All criteria and alternatives selected were developed based upon onsite storage. The exception was a no-action alternative that examined the impact of immediate offsite disposal as embodied in the Ten Year Plan.

Pretreatment of remediation waste for specific Individual Hazardous Substance Sites (IHSSs) is not included in the scope of this document except for the purpose of cost estimating. This is because pretreatment is very specific to an IHSS action and specific waste types. The pretreatment discussion for each accelerated cleanup action would be included in Proposed Action Memorandum, Interim Measures/Interim Remedial Action Decision Documents, and Proposed Plans, or Remedial Action Plans for each specific IHSS or group of IHSSs; allowing treatment to be tailored to the specific action.

Waste acceptance criteria for the proposed RWSF would be addressed based on applicable RCRA and CERCLA requirements as well as applicable DOE policies. The types of requirements are described in Section 7.6, Conceptual Waste Acceptance Criteria. Waste acceptance criteria and operational details would be submitted during the design review and approval process. The scope of the Decision Document does not provide complete details of design, construction, startup, or operations; that information would be covered in subsequent documents following CDPHE designation of the CAMU.

The ability to retrieve and monitor the remediation waste was considered an important part of the decision process, especially in terms of community acceptance. Specific details of environmental monitoring are not in the scope of this document; groundwater monitoring, however, is addressed in Section 7.1; a groundwater monitoring plan will be prepared during the design phase. Air monitoring will be addressed in any air compliance documentation (i.e. APENS, and permit applications) as required to be submitted to CDPHE/EPA. If appropriate, an air monitoring plan will be developed to demonstrate regulatory compliance with Colorado Air Quality Control Commission regulations at the appropriate time.

Closure plans would be prepared and submitted during the design review process. The disposal option discussed in RFCA paragraph 80 is not being considered.

1.2.2 Decision Document Objectives

In order to meet the primary objective of documenting the technical justification for the CAMU and RWSF, this document provides information on how the use of a CAMU can meet each of the seven decision criteria identified in the CAMU regulations (6 CCR 1007-3, Part 264, Subpart S).

The objectives which lead to the determination that a CAMU option is necessary as a contingency to the assumption of offsite disposal of remediation waste as it is generated include the following:

1. In support of RFCA and the Ten Year Plan, the management of low-level, low-level mixed, and hazardous remediation waste must ensure the safety of the public, RFETS workers, and the environment through reliable, effective, protective and cost-effective management of remediation wastes at RFETS. The wastes must be stored in readily retrievable configuration.

2. The solution must support a flexible waste management policy combining contingencies for both long-term storage and short-term staging/storage for offsite disposal while recognizing the uncertainties associated with current waste volume estimates and future offsite disposal availability. A flexible policy would ensure that the most timely and cost-effective strategy that supports RFCA and Ten Year Plan objectives could be implemented

3. The management of low-level, low-level mixed, and hazardous remediation waste must result in a cost-effective solution that would support RFETS Site closure schedules.

4. A means of consolidating remediation waste in one location would be needed to support near-term risk-reduction goals while addressing long-term liability and safety issues and be compatible with future land uses at RFETS.

1.2.3 Drivers

Several drivers established the need for a CAMU designation as a contingency to reach site closure as well as to serve as the basis for both the scope and the objectives of the Decision:

- The Site Vision is to have RFETS cleaned to a level that is consistent with planned future land uses based upon the intermediate site condition as described in the RFCA preamble.
- The Ten Year Plan assumes:
  - that all low-level and low-level mixed wastes would be shipped offsite for disposal
  - that low-level and low-level mixed waste generated in excess of shipping capacity would be managed in new onsite facilities
  - that when ER and D&D activities would begin in earnest, storage facilities would be available to support operations
- The RFCA objective listed in RFCA preamble Section (B) (2) (a) states "Initially controlling the sources of contamination will take priority over off-site waste shipments to maximize risk reduction."
- The need to limit placement of remediation waste in existing permitted units because of a lack of storage capacity.
- The uncertainties associated with the waste volume estimates and offsite disposal availability for D&D and environmental restoration as well as future offsite disposal capabilities for large volumes of waste create a need for a flexible waste management strategy that incorporates a CAMU contingency.

1.3 SITE DESCRIPTION

The Rocky Flats Environmental Technology Site (RFETS) is located in northern Jefferson County, Colorado, approximately 16 miles northwest of Denver (see Figure 1-1). Other surrounding cities include Boulder to the northwest, Broomfield and Superior to the northeast, Westminster to the east, and Arvada to the southeast, all located within 10 miles of RFETS,. The RFETS consists of approximately 6,550 acres of federal land in Sections 1 through 4, and 9 through 15 of T2S, R70W, 6th Principal Meridian. Most of the structures at RFETS are located within a protected central area of approximately 400 acres, and are surrounded by a buffer zone of approximately 6,150 acres.

The RFETS is bounded on the north by State Highway 128, on the east by Jefferson County Highway 17 (also known as Indiana Street), on the south by Highway 72 and agricultural and industrial properties, and on the west by State Highway 93.

The majority of residential development within five miles of RFETS is located immediately northeast, east, and southeast of RFETS. Commercial development is concentrated near residential developments north and southwest of Standley Lake as well as around Jefferson County Airport, approximately three miles northeast of RFETS. Industrial land use within five miles of RFETS is currently only quarrying and mining operations. Open space lands are located northeast of RFETS near the City of Broomfield, in small parcels adjoining major drainages, and in small neighborhood parks in the cities of Westminster and Arvada. The west, north, and east sides of Standley Lake are encompassed by Standley Lake Park open space. Irrigated and non-irrigated croplands, producing primarily wheat and barley, are located north and northeast of RFETS near the cities of Broomfield, Lafayette, Louisville, and Boulder, and in scattered parcels adjacent to the eastern boundary of RFETS. Several horse operations and small hay fields are located south of RFETS. Future land use in the vicinity of RFETS may involve continued urban expansion, increasing the density of residential, commercial, and industrial land use in the areas.

The RFETS is a government-owned, contractor-operated facility, that is part of the nationwide Nuclear Weapons Complex. The Rocky Flats Environmental Technology (RFETS) was operated for the United States Atomic Energy Commission (AEC) from its inception in 1951 until the AEC was dissolved in January 1975. At that time, responsibility for RFETS was assigned to the Energy Research and Development Administration (ERDA), which was succeeded by the United States Department of Energy (DOE) in 1977.

From 1953 through 1989, RFETS was used to produce components for nuclear weapons from materials such as plutonium, uranium, beryllium, and various alloys of stainless steel. Non-nuclear production continued through 1995 in Building 460. Additional plant missions included plutonium recovery and reprocessing, and waste management. Production activities included metal fabrication and assembly, chemical recovery and purification of process-produced transuranic radionuclides. The consequence of these various activities over nearly 40 years was the contamination of some of RFETS soils, groundwater, buildings, process pipelines and associated waste management equipment.

While environmental cleanup and waste management were a part of routine day-to-day operations at RFETS, heightened environmental awareness on a national level and new environmental regulations have expanded and accelerated both activities. The DOE, in response to these changing conditions and the radical change in global politics, set a new mission for RFETS focusing on waste management, environmental restoration, and decontamination and decommissioning of facilities. Consistent with this new mission and with a view toward rapid and safe cleanup, RFCA sets a framework and approach for this final phase of the waste management and cleanup program. The United States Environmental Protection Agency (EPA), the CDPHE, and the DOE have agreed within RFCA to a wide range of objectives leading to the final disposition of the entire RFETS complex. Among these objectives are important areas necessary to responsibly address the environmental consequences of the past 40 years of operation and production.

Current waste management activities include the following:

- Onsite storage, followed by offsite recycling or treatment and disposal of hazardous waste
- Onsite storage, followed by limited onsite treatment and offsite disposal of low-level mixed waste
- Onsite storage followed by offsite disposal of low-level waste
- Onsite disposal of non-hazardous "municipal" type waste

2.0 VERIFICATION OF CAMU DESIGNATION CRITERIA

The ability to designate the RWSF as a CAMU is dependent on compliance with the criteria found in 6 CCR 1007-3 264.552 (c), Corrective Active Management Units (CAMU). In order to demonstrate a need for a CAMU at RFETS, these seven criteria were made an integral part of the decision-making process. Each of the seven CAMU criteria, listed below as numbers 1 through 7, is followed by a description of how the selected RWSF remedy demonstrates compliance with the criterion.

1) The CAMU shall facilitate the implementation of reliable, effective, protective, and cost-effective remedies.

The CAMU designation of the RWSF would support the final remedy of offsite disposal by offering a contingency that supports successfully completing environmental restoration and D&D activities within the accelerated schedule for RFETS closure proposed in RFCA. This CAMU facilitates the remedy of source removal and offsite disposal by allowing risk reduction activities to continue in the event near term offsite shipment is impacted. The ability of the RWSF to provide readily accessible storage capabilities for large volumes of remediation waste, with generally low levels of contamination, would facilitate a reliable, effective, protective, and cost effective remedy by:

- Accelerating IHSS closures by providing a facility for interim storage and/or treatment of contaminated material while simultaneously developing cost-effective offsite disposal capabilities. Currently, the logistics of offsite disposal limit schedules for closing IHSSs and would also impact D&D activities. Designation of a CAMU would allow resources to be focused on supporting near-term risk reduction. Current costs for offsite shipment, treatment, and disposal limit the amount of resources that can be focused on near-term risk reduction, including source removal and D&D.

- Allowing RFETS to minimize costs for treatment, storage, and disposal so that action levels for RFETS closure could be achieved.

The effectiveness of specific cleanup actions would be enhanced by the availability of the RWSF, allowing for a more aggressive remediation schedule. Source materials, including contaminated soils that might have been left in place for a number of years as a continuing source of contamination, would be removed from the environment and placed in the RWSF prior to offsite disposal. With the addition of the RWSF, the schedule for these cleanup activities would not be delayed in the event offsite shipment was delayed.

Because of the modular, compartmentalized design of the RWSF, it would be able to accept a wide variety of remediation waste including D&D waste. Thus, changes in waste form could be accommodated so that operations would not be held up due to unanticipated conditions in the field. For example, if during remedial excavation of soils, a drum or block of concrete was uncovered, this material could be put into the RWSF without shutting down remedial or RWSF operations or requiring extensive paperwork. This availability of immediate storage would facilitate the effectiveness of cleanup actions by allowing the contaminants and source materials to be removed at once and with minimal delay.

The RWSF CAMU alternative would support offsite disposal by offering a protective storage option that supports accelerated risk reduction schedules. This could be considered as an alternative to other closure in place strategies or multiple storage locations.

A number of studies were conducted to provide assurance that the recommended alternative would meet the established criteria for the RWSF. These analyses were conducted to support CAMU criteria for protection of public health and the environment as listed in 6-CCR-1007-3 Part 264.552 (c). The details of the risk evaluation are found in Section 7.3. The analysis of risk was divided into the following three main exposure pathways:

- Offsite transport of contaminants through the groundwater to neighboring surface waters
- Worker exposure to radionuclides during operations
- Offsite fugitive dust emissions

Exposure to the public from infiltration through the underlying geologic strata into the lower Laramie sandstone/Fox Hills drinking water aquifer was considered and ruled out due to the thickness (over 500 ft) of claystone underlying RFETS. Exposures from inadvertent intrusion into the RWSF after closure were also ruled out primarily because the RWSF would be actively managed by inspections and monitoring throughout the life of the facility.

Fugitive dust emission would be addressed by both administrative and engineering controls. Calculations (Appendix G) have shown that the activity levels in soils that would be placed in the RWSF were much lower than activities that would pose a threat to human health at the plant boundary.

Contaminant sources that could impact other site activities and workers as well as generating potential exposures to offsite receptors could be removed from the environment sooner if the RWSF is available. This would facilitate site closure by allowing previously contaminated areas to be cleaned up to interim cleanup levels agreed to in RFCA rather than be closed with contamination above RFCA action levels in place. Once contaminant sources were removed from the environment through D&D, and environmental restoration activities, cost savings could be realized since these areas would no longer require active landlord management. This early closure could result in "mortgage reduction"; i.e., reduced costs of operating RFETS. And the savings achieved from these cleanup activities could be applied to accelerate additional activities supporting RFETS closure.

Treatment requirements which were not necessary to protect human health and the environment could be deferred under the flexibility of the CAMU regulations. This would further allow finite resources to be focused on actual cleanup sooner rather than in the future.

2) **Waste management activities associated with the CAMU shall not create unacceptable risks to humans or to the environment resulting from exposure to hazardous waste or hazardous waste constituents.**

This criteria is meant to address risks that occur during active waste handling and operation of the CAMU (Federal Register, Vol. 58, No. 29, Feb. 16, 1993). Not only would the RWSF CAMU not create unacceptable risks during operation, but it would eliminate risks that might be associated with alternative remedies. The RWSF CAMU would minimize risks to human health and the environment in the following ways:

- Safety precautions would be taken during construction of the facility. All activities would be performed within the extreme safety and radiological protection standards that exist at RFETS. Individuals with expertise specific to construction safety would ensure that construction activities are carried out in a safe manner. Construction quality assurance requirements would ensure that the RWSF would meet all design criteria and performance standards for protectiveness.

- Remediation waste would be removed from the environment and put into an effective and protective facility. No longer would it be exposed to natural transport phenomena that could spread the contamination.

- Initial transportation of the wastes would be performed in a controlled environment over short distances on non-public roads with minimal or controlled traffic. Operations would be closely monitored and safely controlled. Public exposure would be limited during remediation because the waste would not leave the plant site. Because the distances would be so short and the process would be tightly controlled, the risk of transportation accidents during remediation would also be minimized. Administrative and engineered controls would be used to ensure that high winds do not mobilize the contamination during transport. These measures might include precautions such as covered loads, spraying water or other dust suppressants on the loads, high wind shut downs, and other appropriate precautions.

- Safety during filling of the facility would also be closely monitored and controlled. Precautions being considered include spraying the waste for dust suppression, keeping the waste covered, high wind shut downs, and appropriate personal protective equipment. All filling activities would be conducted under appropriate health and safety plans.

- An operational cover would be installed to protect the waste from exposure to the elements during remediation.

Indirect effects and cumulative impacts of the Environmental Restoration program at Site would be reduced by utilizing the centralized RWSF built on a previously disturbed and contaminated area. Impacts to the environment would be minimized because the footprint of contaminated areas would be reduced to one facility compared to multiple IHSSs that now exist. Irreversible commitment of resources (soil and ecological) has already occurred at the Solar Ponds location due to the installation of the Solar Ponds and related facilities.

3) The CAMU shall include uncontaminated areas of the facility, only if including such areas for the purposes of managing remediation waste is more protective than management of such wastes at contaminated areas of the facility.

This CAMU criteria requires justification for selecting a CAMU in an uncontaminated location, and it was a major influence upon the selection of the RWSF location east of the Solar Ponds. The location selected is in an area previously affected by waste management activities and thus meets this criteria (Federal Register, Feb. 16, 1993). The proposed RWSF location east of the Solar Ponds overlaps with the following areas of contamination:

- **IHSS 165 - The Triangle Area** This IHSS was part of the former OU 6. Drums containing plutonium-bearing wastes were stored in this area. The drums leaked and contaminated the soil. In 1973, 200 cubic yards of soil were removed from this site.

- **IHSS 176 - Swinerton and Walberg Contractor Storage Yard** This IHSS was part of the former OU 10. Water spray from the Solar Ponds blew into this area. Also, leaking drums containing waste oils and volatile organic compounds were stored here. Volatile organic compounds were detected during the soil gas survey characterization of this site.

- **IHSS 101 - Solar Ponds Area** These were former OU 4 solar evaporation ponds which were used for storage and evaporation of liquid low-level radioactive waste. All of the sludge was removed from the Solar Ponds but the liners are still in place. The proposed CAMU location overlaps the eastern edge of the ponds. Additional facilities could be placed on the ponds themselves if expansion of the RWSF is needed and designated in the future. Placement of the facility at this location would be expected to facilitate remediation operations at the Solar Ponds.

- **Building 964** - This building housed low-level waste storage. It was also exposed to the water spray coming from the solar ponds.

Although this area is contaminated, it was not expected that placement of the RWSF in this area would hamper any cleanup operations. Likewise, the levels of contaminants that would be found at the RWSF construction site were not expected to hamper its construction or operation.

4) **Areas within that CAMU, where remediation wastes remain in place after closure of the CAMU, shall be managed and contained so as to control, minimize, or eliminate future releases to the extent necessary to protect human health and the environment.**

This criterion was not applicable. The designated use of this facility is for monitored, retrievable waste storage.

5) **The CAMU shall expedite the timing of remedial activity implementation, unless to do so would be inconsistent with 264.552 (c)(1) or (c)(2)** (See criteria 1 and 2 above)

Once constructed, the facility would expedite remedial activities. Waste would be transported directly from excavation or treatment into the RWSF. Planning documents for cleanups would be simplified since the waste management methodology would be established. It would be possible to establish work crews that could clean up IHSSs in an almost assembly-line fashion, moving from IHSS to IHSS with the necessary equipment while trucks transport the remediation waste to the RWSF. Concurrent to these activities, new modules to the RWSF could be constructed so that there would be sufficient capacity available to accept the waste. Crews could be simultaneously performing D&D and environmental restoration, moving from building to building, and transporting these waste materials to the RWSF. Without the RWSF, cleanup and D&D activities may be limited by the rate at which wastes can be shipped off site.

6) The CAMU shall enable the use, when appropriate, of treatment technologies (including innovative technologies) to enhance the long-term effectiveness of remedial actions by reducing the toxicity, mobility, or volume of remediation waste that will remain in place after closure.

This criterion is not applicable . The designated use of this facility is for monitored, retrievable waste storage.

7) The CAMU shall minimize the land area of the facility upon which remediation wastes will remain in place after closure of the CAMU unless to do so would be inconsistent with 264.552 (c)(1) or (c)(2) (See criteria 1 and 2 above)

This criterion is not applicable . The designated use of this facility is for monitored, retrievable waste storage.

3.0 WASTE CHARACTERISTICS

3.1 REMEDIATION WASTE CHARACTERIZATION

General waste types characteristics and volumes which may be placed into the RWSF are described in this section. Identification of waste characteristics, sources, and projected volumes for the RWSF clarify and substantiate the need for a contingency to existing waste storage. Only remediation waste would be considered for management in this facility. Conceptual waste acceptance criteria for the RWSF are discussed in section 7.0. No process waste would be accepted.

Remediation waste, is defined by RFCA in part 5, paragraph 25 bf:

> 1) solid, hazardous, and mixed wastes; (2) all media and debris that contain hazardous substances, listed hazardous or mixed wastes or that exhibit a hazardous characteristic; and (3) all hazardous substances generated from activities regulated under this Agreement as RCRA corrective actions or CERCLA response actions, including decommissioning. Remediation waste does not include wastes generated from other activities. Nothing in this definition confers RCRA or CHWA authority over source, special nuclear, or byproduct material as those terms are defined in the Atomic Energy Act.

The potential contaminants of concern in remediation waste include:

- Radionuclides (such as plutonium, americium, and uranium)
- Metals (such as cadmium and chromium)

  Volatile organic compounds (such as carbon tetrachloride, trichloroethene [TCE], tetrachloroethene [PCE])
- Semivolatile organic compounds
- TSCA consitituents such as PCB or asbestos (to be managed per applicable TSCA regulations)

Low-level waste, as defined by RFCA, has a radionuclide activity less than 100 (nCi/g) nanocuries per gram. In addition, RFCA defines low-level waste as "radioactive waste that is not high-level waste, spent nuclear fuel, by-product material, or transuranic waste (although it may contain small amounts of transuranic elements)." The majority of the low-level waste managed at the RWSF would have a radionuclide activity much less than 10 nCi/g based on the Hazard Categorization Analysis (see Section 9.0, Kaiser-Hill, 1996a). Acceptable waste media and forms (e.g., under 6 CCR 1007-3 Part 264.312-264.317, subpart N) for placement in the RWSF were modeled after Landfill restrictions, which include the following:

- No free liquids
- No compressed gases
- No transuranic (TRU) waste

- No incompatible wastes (such as pyrophoric uranium)
- No ignitable or reactive wastes

Remediation waste types include:

- Contaminated soil collected from remedial actions
- Treated and untreated sludge and sediments (e.g. Solar Ponds sludge)
- Toxic Substance Control Act (TSCA) waste (such as asbestos and PCBs)
- Treatment by-products from groundwater, surface water, and/or soil remediation actions
- Residual from the Solar Evaporation Ponds; e.g. portions of the liners would be considered remediation waste
- IDM from past and future characterization activities, such as wells, and borings, if the IDM is characterized as hazardous, low-level, or mixed remediation waste
- D&D waste which has been characterized as hazardous, low-level, or mixed waste; it includes building rubble, equipment, and utilities removed from the building prior to demolition. D&D waste does not include deactivation.

The low-level mixed waste and hazardous waste placed in the RWSF would consist of the remediation waste currently stored at RFETS and the remediation waste which would be generated in the future.

3.2 REMEDIATION WASTE VOLUME

Waste volume estimates were based on planned risk reduction activities. A preliminary estimate of remediation waste volumes is presented in Table 3-1 below. The total volume of remediation waste was estimated to be 94,100 m^3 or 123,200 cu yd which would be placed in a RWSF. These estimates were based on current information and coincide with the Ten Year Plan waste volumes. These volume estimates were not intended to limit the size of the facility, but serve as a tool to create alternatives for the decision making process.

The actual volume of soil defined by Tier 1 and Tier 2 cleanup levels in RFCA could be larger or smaller because volume estimates were made with preliminary data from limited characterization. Final volumes would be determined in the field based on RFCA action levels.

Table 3-1 Estimated Remediation Waste Volumes for the Remediation Waste Storage Facility

Remediation Waste Types	Total Estimated Volume (m^3)	Total Estimated Volume (yd^3)	Volume Ranges (m^3)
Low Level Waste	40,700	53,300	32,600 m^3 to 81,400 m^3
Low Level Mixed Waste	53,400	69,900	42,800 m^3 to 106,900 m^3
Total	94,100	123,200	75,300 m^3 to 188,300 m^3

Notes:

1. These waste volumes are estimated within a range of -20% to +100%.

4.0 IDENTIFICATION OF SUBSTANTIVE CRITERIA

This section presents the substantive criteria that 6 CCR Subpart 5 and RFCA require for a CAMU to be designated at RFETS. Paragraph 80 of RFCA provides: "[I]f the application meets the appropriate substantive criteria CDPHE will issue a CAMU designation." Likewise, the CAMU rule, promulgated pursuant to the CHWA, states that "[t]he Department shall specify, in the permit or order, requirements for CAMUs..." (See 6 CCR 1007-3, Part 264.552 (e).

4.1 RESOURCE CONSERVATION AND RECOVERY ACT CAMU CRITERIA

The designation of a Corrective Action Management Unit must be performed in accordance with the seven criteria enumerated in 6 CCR 1007-3, Part 264.552(c). The seven CAMU criteria were also discussed in section 2.0 and listed in appendix A of this document:

1. The CAMU shall facilitate the implementation of reliable, effective, protective, and cost-effective remedies.

2. Waste management activities associated with the CAMU shall not create unacceptable risks to humans or to the environment resulting from exposures to hazardous waste or hazardous waste constituents.

3. The CAMU shall include uncontaminated areas of the facility only if including such areas for the purposes of managing remediation waste is more protective than management of such wastes at contaminated areas of the facility.

4. Areas within the CAMU, where remediation wastes will remain in place after closure of the CAMU shall be managed and contained so as to control, minimize, or eliminate future releases to the extent necessary to protect human health and the environment;

5. The CAMU shall expedite the timing of remedial activity implementation unless to do so would be inconsistent with 264.552 (c) (1) or (c) (2).

6. The CAM shall enable the use, when appropriate, of treatment technologies (including innovative technologies) to enhance the long-term effectiveness of remedial actions by reducing the toxicity, mobility, or volume of remediation waste that will remain in place after closure of the CAMU; and

The CAMU shall minimize the land area of the facility upon which remediation wastes remain in place after closure of the CAMU, unless to do so would be inconsistent with 264.552 (c) (1) or (c) (2).

4.2 RFCA Requirements

The requirements under RFCA for CAMU designation are presented in paragraphs 80 and 109 of RFCA. Section 7.4 of this document discusses how the selected design addresses the RFCA requirements. Paragraph 80 of RFCA states:

> that the design criteria for the facility described in this paragraph shall be the same whether the facility is for the retrievable, monitored storage of remediation wastes or for the disposal of remediation wastes. Specifically, the facility described in this paragraph must ensure retrieval of wastes and protection of human health and the environment through a combination of requirements that include, but are not limited to: detection and monitoring/inspection requirements; operating and design requirements, including cap/liner system that meets the requirements as set forth in 6 CCR 1007-3, Part 264, Subpart N; a groundwater monitoring system; and requirements for responding to releases of wastes or constituents from the units. In addition, where necessary for protection of human health and the environment, waste treatment will be required. If DOE proposes a CAMU, it is the expectation of the parties that if the application meets the appropriate substantive criteria, CDPHE will issue a CAMU designation for storage or disposal in a timely fashion.

In response to RFCA paragraph 80, the following design and operating requirements would be addressed and implemented. These requirements are discussed in Section 7 for the specific selected alternative, the Concrete-Lined Cell:

- leak detection (Section 7.1, 7.4)
- inspections (7.4)
- a cap/liner system that meets RCRA Subpart N requirements (Section 7.1, 7.4)
- a groundwater monitoring system (Section 7.1, 7.4)
- corrective action for releases (Section 7.4)
- a waste acceptance criteria, consistent with design and operation, that provides treatment of wastes where necessary (Section 7.6)

In addition, as part of the IM/IRA process, paragraph 109 of RFCA also directs DOE to present an analysis of alternatives showing that DOE has considered the following:

- worker safety
- protection of human health and the environment
- transportation
- facility design, containment, and monitoring
- institutional controls
- cost
- community acceptance

The consideration and evaluation of the above RFCA criteria are addressed in Section 6.0 and summarized in table 6-1.

4.3 CAMU Requirements

After the CAMU designation is received, the DOE would be required to submit detailed plans as to how the following requirements would be met. In the event that a CAMU is necessary, these plans would be submitted during the design phase.

Six CCR Subpart S, Part 264.552 (a) (2) states:

> For the purposes of the application of the minimum technology requirements of 40 CFR Part 268.5 (h) (2); or of the minimum technology requirements of Subparts K, L, M, or N; or the groundwater protection requirements of Subpart F; or the closure and post-closure requirements of Subpart G of part 264 or 265 of these regulations; consolidation or placement of remediation waste into or within a CAMU does <u>not</u> constitute creation of a regulated unit.

Part 264.552 (a) (3) requires:

> Where the remediation wastes placed into a CAMU are hazardous wastes, the CAMU shall comply with Subparts B, C, D, and E of Part 264 or 265 of these regulations and, when such remediation wastes will remain in place after closure of the CAMU, the CAMU shall comply with the regulations for the siting of hazardous waste disposal sites, 6 CCR 1007-2, Part 2.

The intent of 6-CCR-1007-3 Subpart C 265.35 is to provide access to areas of the facility, as necessary, to support emergency operations in the event of spills or fire. Since the bulk storage areas contain wastes that are limited by the waste acceptance criteria to containing no free liquids and being non-flammable, aisle space is not necessary for these areas. Access to areas where electrical components or leachate collection sumps are located will not be impeded.

Additional requirements for designation are enumerated in 6 CCR Part 264.552(e) of the CAMU rule. The following are the additional requirements after the designation of the CAMU (Compliance with these requirements is discussed in section 7.7):

- specification of the area configuration, Part 264.552 (e) (1))
- specification of the design, operation, and closure requirements (Part 264.532 (e) (2)
- specification of groundwater monitoring requirements specific to (Part 264.552 (e) (3)
- specification of closure and post closure requirements (Part 264.552 (e) (4)

5.0 SCREENING OF ALTERNATIVES

A two-phase decision-making process was developed for screening and selecting remediation waste management storage alternatives that support the best remediation waste management strategy for RFETS. The first phase evaluated different onsite locations and the second phase evaluated conceptual storage design alternatives. The onsite location selected was then coupled with the conceptual storage design alternative for inclusion in the Final Comparison of Alternatives (Figure 5-1, Decision Process for Remediation Waste Management).

5.1 PHASE 1 - ONSITE REMEDIATION WASTE STORAGE FACILITY SITING STUDY

The selection of a location for a RWSF at RFETS is detailed in Appendix C, Onsite Remediation Waste Storage Facility Siting Study. The objective of Phase I was to evaluate and select an onsite location for a RWSF. The method used was as follows:

- Identify and rank criteria to be used for siting of an onsite RWSF location.
- Develop a methodology for a comparative analysis of different sites.
- Evaluate the criteria subjectively and assign a relative weighting factor to each criteria.
- Recommend an onsite location based on the above criteria and methodology.

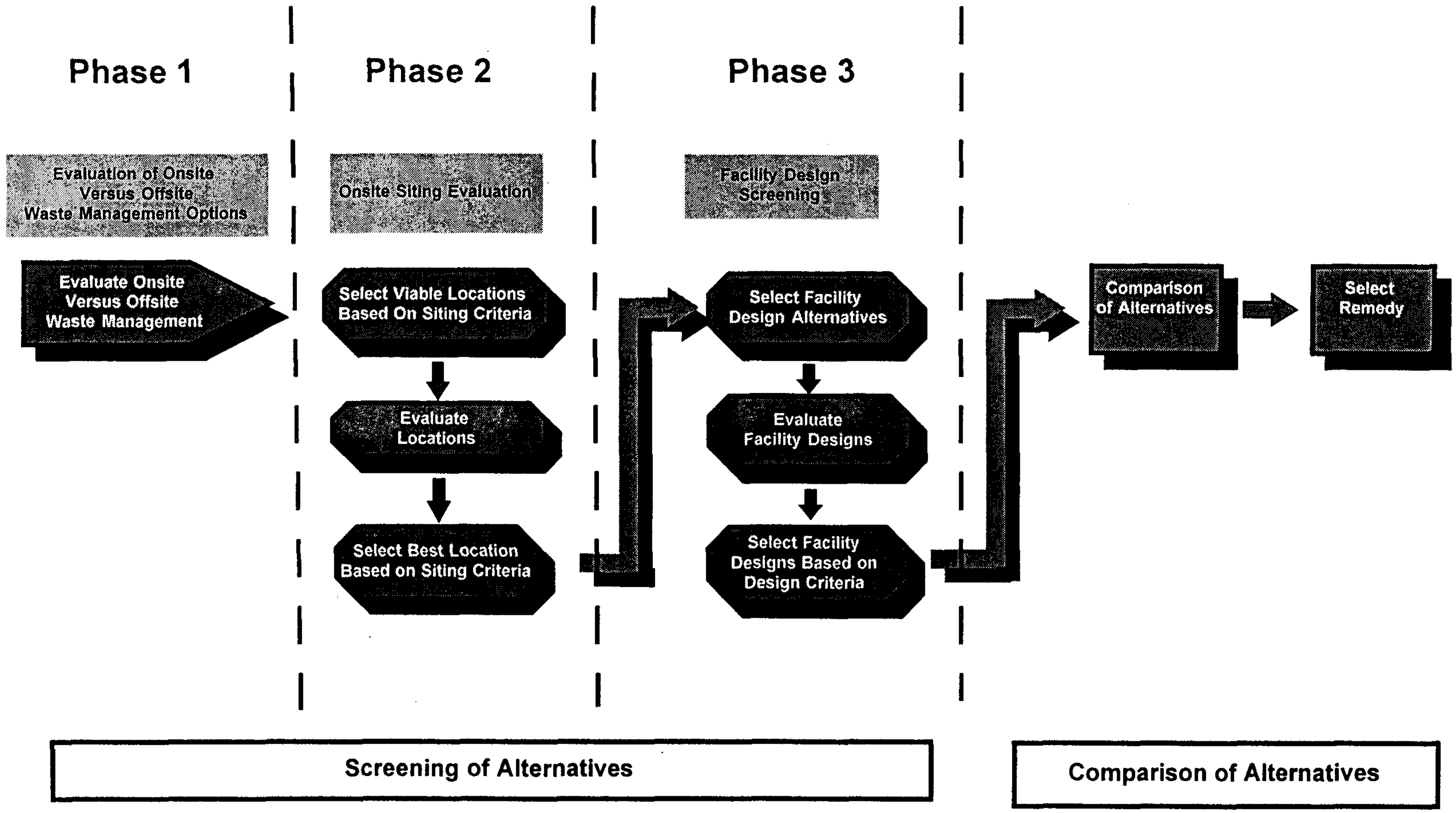
This process is described below.

1. Identify and rank criteria to be used for siting an onsite RWSF location. This criteria required, at a minimum meeting the substantive requirements as discussed in Section 4, as well as general guidelines that had been discussed at various stakeholders' meetings regarding a RWSF at RFETS. The criteria were then organized into the six major categories summarized below and further divided into specific issues within each of these major categories. Details of the criteria are in Appendix D.

i. The ability to designate the RWSF as a CAMU: All CAMU criteria were evaluated, but the deciding criteria was the ability to facilitate the implementation of reliable, effective, protective, and cost-effective remedies and not include uncontaminated areas of RFETS in the footprint of the RWSF 6 CCR-264,552 (b)(3) (Looby, 1995).

ii. The ability to ensure the protection of the public, per 6 CCR 1007-2 Part 2, Requirements for Siting of a Hazardous Waste Disposal Site: Although the RWSF would be a storage facility, some of these criteria, which relate to long-term disposal, were used to evaluate locations for storage as an additional degree of protectiveness. The following criteria, based upon 6 CCR 1007-2 Part 2, Requirements for Siting of a Hazardous Waste Disposal Site, were used in the evaluation:

Figure 5-1 Decision Process For Remediation Waste Management



1. The geological and hydrogeologic conditions, combined with engineering controls, of a location in which hazardous waste is to be stored should be such that reasonable assurance is provided that the wastes are isolated within the storage area away from exposure pathways to the public.

2. Geomorphic conditions either will not vary significantly from the present state or will occur to a predictable degree, which can be accommodated in the facility design.

3. Structural-related issues include slope and geotechnical stability.

4. The immediate area of the location should be in strata of minimal groundwater flow.

5. Geological strata combined with engineering barriers shall provide minimum permeability.

6. Siting consideration should include bedrock and surface integration including the nature and extent of bedrock material.

7. Siting consideration should include minimal relative presence of fractures or faults.

8. Consideration should be given to the relative depth to bedrock of groundwater, including seasonal fluctuations of groundwater.

9. The Site will not impact nor be impacted by surface water.

10. Relative distance to nearest discharge area shall include consideration of groundwater flow direction and travel time.

11. The terrain is such that good drainage exists for movement of precipitation away from the storage area, and such that water and wind erosion will be minimal.

iii. The ability to support the RFCA. The Preamble to RFCA Section B.2 states: "Waste management activities for low-level, low-level mixed, hazardous, and solid wastes would include a combination of onsite treatment, storage in a retrievable and monitored manner, disposal, and offsite removal. Low-level and low-level mixed wastes generated during cleanup would be stored in a safe, monitored and retrievable manner for near-term shipment offsite, long-term storage with subsequent shipment offsite and/or long-term storage with subsequent disposal onsite of the remaining wastes."

iv. Cost must be evaluated including the cost of pre-construction activities, and the following:

- Building demolition
- Subsurface utility line removal and re-routing
- Access requirements and power/facility requirements

— The cost of engineering and construction of protective measures

v. Regulatory Support was focused on using CDPHE guidelines (Looby, 1995) for onsite waste management of contaminated materials. Key points evaluated include the minimization of the number of disposal sites, consolidation of contaminated materials, and having a centralized site in an area with optimum geologic parameters preferably close to or within the Industrial Area with limited future land use.

vi. Other Stakeholder concerns that must be include the general acceptance of the RWSF by the general public and the Municipal or County governments.

2. Develop a methodology for comparative analysis of the different sites: A basic assumption was that the entire RFETS, both within the buffer zone and the Industrial Area, would be included in the evaluation. A series of Geographical Information System (GIS) maps were produced to assist in this evaluation. These maps, which included key elements cited in the criteria, were evaluated for being beneficial or adverse to the siting of a RWSF.

The initial evaluation of the sites reduced the number of potentially useable locations to seven, with four in the buffer zone and three in the Industrial Area.

The following are Potential Industrial Area sites:

- Industrial Area-West (IA-West), an area on the west side of the Industrial Area
- Industrial Area-East (IA-East), an area on the east side of the Industrial Area
- Solar Ponds, an area adjacent and east of the Solar Pond in the northeast section of the Industrial Area

The following are potential buffer zone sites:

- The New Sanitary Landfill (NSL)
- An area encompassing the East Spray Fields (ESF)
- An area in the southeast quadrant (SE Quad) of the buffer zone
- An area in the southwest quadrant (SW Quad) of the buffer zone

3. Evaluate the criteria subjectively and assign a relative weighting factor to each of the criteria: For a more detailed description of the methodology see Appendix C, Section C.2.2, Methodology.

First, the methodology that was applied began by developing a relative weighting factor (%) based subjectively on the importance of each of the six categories of criteria as shown under Table 5.1.

Second, the categories were divided into 38 specific issues. Each of the issues was subjectively assigned a value between 0 and 3, with a 3 being a more important issue, 1 being less important, and a 0 being a potential fatal flaw.

Third, a matrix was developed using the 7 locations versus the 38 issues (see Appendix C, Table C-2). A score was assigned relative to the other sites and the criteria being evaluated. A score of 0 for any of the 38 issues signified a fatal flaw and the site was withdrawn from further consideration in the evaluation.

Table 5-1 Methodology Weighting Factors

Category	Criteria	Weighting Factor (%)	Number of Specific Issues	Total Number of Points Assigned
1	Corrective Action Management Unit (CAMU)	15	7	19
2	Public Protection (Geotechnical and Hydrological Criteria)	20	12	28
3	RFETS Special Issues	20	8	15
4	Cost Criteria	15	2	6
5	Regulatory Support	15	5	13
6	Other Stakeholder Concerns	15	4	9
	*** Total**	**100**	**38**	**90**

* A weighted average was arrived at for each of the categories and the values were summed.

4. Recommend an onsite location based on the above criteria and methodology: The location receiving the highest score was the recommended onsite location for a RWSF (see Appendix C, Section C.2.3, Table C-5). The location recommended for a RWSF is the area in the northeast corner of the Industrial Area adjacent to and east of the Solar Ponds (see Figure 5-2).

5.2 PHASE 2 - SCREENING OF ONSITE DESIGN OPTIONS

The objective of Phase 2 was to select and evaluate different design options for an onsite RWSF. A list of innovative RWSF designs was developed. This list was compiled from literature and input from the Citizen's Advisory Board (CAB), current RFETS practices, and designs in use at other facilities in the United States and Europe. These design options are either actual facilities in use or under consideration elsewhere (see Appendix E, Remediation Waste Storage Facility Design Alternatives). All of these design alternatives are contingencies to the assumption in the Ten Year Plan which calls for offsite disposal as remediation waste is generated and assume that the storage and schedule assumptions in the Ten Year Plan are not valid. This means that the No Action alternative is no action relative to the contingency options only and not the same as the Ten Year Plan.

The following design alternatives were proposed for the screening process:

- Pyramid- Bulk waste would be enclosed in a rectangular pyramid constructed out of granite blocks; alternative proposed at a meeting of the CAB by a member of the public

- Metal Buildings - Waste would be enclosed in cargo containers placed inside engineered metal buildings on concrete slabs; this is RFETS' current practice to store LLW and LLMW

- Slab on Grade - Waste would be stored in cargo containers placed on an abovegrade concrete slab; This is current practice at some DOE/DOD sites including RFETS, which stores much of its LLW in a similar manner

- Hardened Concrete Vault - Waste would be stored in cargo containers and placed in an abovegrade freestanding concrete structure with liners and a leachate collection system; this is a current practice at the DOE Savannah River Site for LLW & LLMW

- Concrete-Lined Cell with bulk placement - Bulk waste would be placed in modules in concrete-lined cell. Under the cell would be a liner and a leachate collection system

- Concrete-Lined Cell in Cargo Containers - Waste would be stored in cargo containers and placed in modules in concrete-lined cell. Under the cell would be a liner and a leachate collection system

- Abovegrade Storage Cell - Earthen structure similar to a RCRA cell except facility would be constructed Abovegrade with berms and a liner/leachate collection system; alternative as proposed would be similar to current practice around the nation to meet RCRA-Subtitle C, requirements

- Silo - Bulk waste would be placed in concrete cylinders which sit on top of a concrete pad. Under the pad would be a liner/leachate collection system; this alternative was proposed in an interim report by the Idaho National Engineering Laboratory (INEL) (EG&G, 1994)

- Entombment - Waste would be placed in 55 gallon drums and then sealed with grout in concrete boxes which would be stored in a hardened concrete vault. This alternative was proposed in an interim report by the INEL (EG&G, 1994)

- Waste Pile - Bulk waste would be compacted into a rectangular pile with all sides covered with a geomembrane. A liner system would be place under the pile. This alternative was based on the Interim Remedial Action for Basin F, Rocky Mountain Arsenal

- No Action (i.e., no CAMU designated Remediation Waste Storage Facility) - Remediation waste would have to be treated and shipped to an offsite disposal facility as soon as it was recovered, stored at the action-specific locations until offsite shipment could occur, or cleanup actions would be delayed until waste could be shipped offsite. This alternative defines no action as specific to construction of an onsite storage CAMU and assumes that although site cleanup would continue, accelerated risk reduction schedules would be delayed.

The initial conceptual design screen, summarized in Table 5-2, which used the same criteria as the Siting Study, narrows the 11 design alternatives to four final design alternatives. The alternatives shaded in the table represent the alternatives carried into the final screen. Table 5-3 is a cost comparison of the 11 design alternatives.

Table 5-2 Summary of Facility Design Screen

Facility Design	CAMU Criteria	Public Protection (Geotechnical and Hydrological Criteria)
Pyramid	Not effective because of schedule concerns for expediting cleanup and higher costs. Hard to monitor. Reliability is not proven. Retrieval difficult.	Structure could experience differential settlement and breach the barrier. Rigid structure not as elastic as other alternatives.
Silo	Minimizes land area by consolidation of waste to one location. Retrieval difficult.	Alternative provides barriers and leachate collection to protect groundwater and surface water.
Metal Buildings Selected for further evaluation.	Intended as a short-term storage option with periodic maintenance. Costs are high due to bulk containers. Large area footprint because of number of buildings required. Retrieval would be easy.	Short-term storage. For up to 30 years it would provide adequate protection to environment. Protective barrier is the building shell and containers.
Slab on Grade	This alternative is a short-term storage option. Waste would be more exposed. Land area would be minimized. Retrieval would be difficult.	Exposes containers to the weather elements, has a greater risk of releases to surface water or groundwater. No barriers.
Hardened Concrete Vault	Not cost-effective because of storage containers and rigid structure. Good retrievability with a larger footprint because of accessible aisles.	Provides multiple barriers to limit release of contaminants with a leachate collection system. Enclosed concrete structure and containers provide additional protection.
Concrete-lined Cell with Bulk Placement Selected for further evaluation.	A good mix of cost-effectiveness and protectiveness. Supports expediting cleanup activities because of modular design with integral separation walls for good retrievability.	Provides numerous barriers to limit release of contaminants with a leachate collection system.
Concrete-lined Cell In Cargo Containers	Good retrievability but higher costs than Concrete-lined Cell because of waste containers.	Provides numerous barriers to limit release of contaminants with a leachate collection system. Containers provide additional protection.
Abovegrade Storage Cell Selected for further evaluation.	Provides good support for remedial activities, minimizes risk of future releases. Retrievability is moderate due to bulk placement.	Groundwater diversion measures, liners and leachate detection/collection system provides reliability, and protection to groundwater.
Waste Pile	Retrieval is difficult, similar to Abovegrade Storage Cell.	Short term Storage. No protective barriers or leachate collection.
Entombment	Good protection to environment and public. Larger footprint because of smaller containers for storage of wastes. Retrieval is good.	Provides additional barriers other than the multiple liners and leachate detection (i.e., concrete canisters and drums).
No Action Selected for further evaluation.	Individual remedial actions would require handling the waste separately by temporary storing with ultimate offsite disposal or deferring cleanup. No retrieval necessary.	Individual remedial actions would require handling the waste separately by temporary storing for ultimate offsite disposal or deferring cleanup.

Table 5-2 (continued)

Facility Design	Site Special Issues	Cost Criteria
Pyramid	Does not provide an expeditious construction schedule because of logistics in acquiring the granite blocks. Does not support Site Vision.	This alternative fell in the middle of the range for total life-cycle costs.
Silo	Supports Site Vision and RFCA, relatively small footprint.	Cost-effective, third lowest total life-cycle cost due to small footprint .
Metal Buildings	Large footprint because of multiple facilities. Simple design allows quick construction.	Total cost is high due to cost of containers and multiple buildings.
Slab on Grade	Simple design allows quick construction. A short-term storage solution.	Total cost is high due to cost of containers.
Hardened Concrete Vault	Meets this criteria better than most designs, smaller footprint reduces impacts.	This option fell in the upper end of the cost range because of containers and free- standing rigid structure.
Concrete-lined Cell with Bulk Placement	Supports Site Vision and RFCA, small footprint, less impact to other RFETS programs. Flexible, modular type facility.	Low construction, site preparation, and closure costs yielded the second lowest total life-cycle cost of any of the alternatives.
Concrete-lined Cell In Cargo Containers	Supports Site Vision and RFCA, less impact to other projects.	This option fell in the middle of the cost range because of the cost of containers.
Abovegrade Storage Cell	Large footprint could cause additional impacts, supports Site Vision and RFCA.	Low total life-cycle cost in spite of high construction costs.
Waste Pile	Short term solution, consolidates wastes to one location, small footprint. Does not support RFCA or necessary requirements	Low life cycle costs due to a lack of protective features.
Entombment	The largest footprint of all alternatives. Construction would be very time-consuming and costly.	The most expensive alternative, highest life-cycle costs because of the double containment (drums and concrete bins).
No Action	Would impact cleanup and shipment schedules.	Includes only shipping and offsite disposal costs.

Note: Costs for offsite shipment and disposal are included only in the **No Action Alternative.**

Table 5-2 (continued)

Facility Design	Regulatory Support	Other Stakeholder Concerns
Pyramid	Design is not state of the art. No barrier systems or leachate detection other than the solid granite walls.	Questionable design/technology. Availability of materials in a timely fashion is uncertain.
Silo	Limited flexibility for future uses. Consolidation of waste in one footprint.	Design is not widely used. Protects environment and public. Retrieval would be more difficult.
Metal Buildings	Large footprint poor consolidation of wastes since multiple buildings are required.	Proven technology and easy to implement quickly.
Slab on Grade	Small footprint for consolidation of wastes. Not a state of the art facility.	Provides only minimal barriers for protection of environment. Proven technology and easy to implement quickly.
Hardened Concrete Vault	Long-term waste management. Protects environment and public.	Proven technology but it would take more time and effort to construct.
Concrete-lined Cell with Bulk Placement	Long-term waste management that consolidates waste into modular/flexible facility.	Provides good protection to the environment and public health.
Concrete-lined Cell In Cargo Containers	Long-term waste management that provides good protection to public and environment. Retrievability is a little better than some alternatives because of accessibility to containers.	Provides good protection to the environment and public.
Abovegrade Storage Cell	Provides good protection to the public and environment. Consolidates wastes into one location.	Proven technology because of past performance. Retrievability is achievable but fair because waste is in bulk quantities.
Waste Pile	Short-term solution. Provides good protection to public and environment. Not designed to meet RCRA considerations.	Short-term solution.
Entombment	Provides enhanced protection to the public and environment by the additional containers. Footprint is enlarged because of unusable/wasted space.	Waste retrieval is good because waste is segregated in concrete bins and drums. Longer construction schedule because of the complexity and number of drums to handle.
No Action	Limited onsite storage capabilities would delay cleanup.	Risk reduction activities would be delayed.

Table 5-3 Comparison of Design Alternative Costs (Cost in thousands of dollars)

Alternative	Abovegrade Waste Cell	Pyramid	Concrete-lined Cell Bulk Placement	Concrete-lined Cell w/Containers	Hardened Concrete Vault
Total Cost [1]	$119,200	$141,800	$79,120	$167,450	$185,130
Cost of Construction					
Design	$2,200	$2,200	$1,600	$1,600	$2,200
Construction Management	$400	$400	$150	$150	$400
Construction	$41,700	$57,900	$18,600	$18,600	$26,000
Total Cost of Construction	$44,300	$60,500	$20,350	$20,350	$28,600
Cost of Site Preparation	$8,800	$14,500	$1,970	$1,970	$6,100
Cost of Closure					
Cap	$5,300	N/A	$5,300	$5,300	$5,300
Monitoring	$13,900	$13,900	$13,000	$10,400	$10,400
Final Closure	$400	$1,500	1,800	$1,800	3,500
Total Cost of Closure	$19,600	$15,400	$20,100	$17,500	$19,200

Table 5-3 (cont.) Comparison of Design Alternative Costs (Cost in thousands of dollars)

Alternative	Silo	Slab on Grade	Metal Buildings	Entombment	Waste Pile	No Action
Total Cost [1]	$114,300	$143,400	$1664,000	$533,800	$36,969	$0
Cost of Construction						
Design	$2,000	$300	$2,300	N/A [3]	N/A [3]	N/A [3]
Construction Management	$400	$200	$1,300	N/A [3]	N/A [3]	N/A [3]
Construction	$30,400	$3,800	$17,900	N/A [3]	N/A [3]	N/A [3]
Total Cost of Construction	$32,800	$4,300	$21,500	N/A [3]	N/A [3]	N/A [3]
Cost of Site Preparation	$6,100	$6,100	$2,800	N/A [3]	N/A [3]	N/A [3]
Cost of Closure						
Cap	$5,300	N/A	N/A	N/A [3]	N/A [3]	N/A [3]
Monitoring	$13,900	$8,500	$10,400	N/A [3]	N/A [3]	N/A [3]
Final Closure	$7,000	$1,800	$2,600	N/A [3]	N/A [3]	N/A [3]
Total Cost of Closure	$ 26,200	$10,300	$13,000	N/A [3]	N/A [3]	N/A [3]

Footnotes:

1. Total costs also include costs for containers, permitting, operations, contingency, etc. More detailed estimates are presented in Appendix E.
2. The cost for waste retrieval and disposal is not included for any of the alternatives . It is assumed that these costs are approximately equal for all the alternatives.
3. Costs for these alternatives were not broken down because of the following:
   - Entombment costs were based on a projected total cost that did not address specific costs.
   - Waste Pile costs were based on actual costs from Rocky Mountain Arsenal Cleanup in Colorado
   - These costs were not applicable for The No Action alternative.

The following four selected alternatives reached the final screening:

- Abovegrade Storage Cell
- Concrete-lined Cell with bulk placement
- Metal Buildings
- No Action Alternative

Several of the factors which affected the selection of these alternatives for the final comparison are explained below.

The Abovegrade Storage Cell alternative was retained for further evaluation for several reasons. First, it is proven technology. Second, the liners and leachate collection system would provide the ability to detect leaks and recover contaminants prior to entering the environment. Third, this alternative would offer flexibility, retrievability and still remains one of the least expensive over the long term. Finally, this alternative would support RFCA in terms of design requirements, and would support the 10 Year Plan by providing the necessary flexibility. This alternative would be similar to the standard hazardous waste landfill built to RCRA Subtitle "C" standards and would be built above the existing grade to prevent groundwater infiltration.

The Concrete-lined Cell with bulk placement alternative was retained for further evaluation for several reasons. First, the concrete cell would add another layer of protectiveness to groundwater from the leachate generated during placement and storage operations. Second, this alternative would be flexible and would allow for modular installation that would optimize the sizing of the cells and timing of the installation as waste is generated. For example, the first module would be sized for 25,000 to 33,000 cu yd of waste, and therefore, can be installed more quickly. Subsequent cells would be added as needed up to a total capacity of approximately 100,000- 300,000 cu yd. . This flexibility would also expedite risk reduction activities under the Site Vision. Third, this alternative provides a fair degree of retrievability because it uses a combination of containers and bulk storage. Finally, this alternative would meet the RFCA requirements in 6 CCR 1007-3, Part 264, Subpart N. which allows the flexibility to utilize the facility for either short-term or long-term storage.

The Metal Buildings alternative was retained for further evaluation because it would allow for interim storage of the waste until the final disposition is determined. Storage of waste would allow remediation to proceed in a timely fashion. The waste would be stored in cargo containers and could be fully monitored and recovered. It was, therefore, believed that public perception and acceptance of this alternative would be high despite the higher cost and shorter life.

The No Action alternative was retained since from a cost basis this is the most effective approach. This alternative assumes that cost is the deciding factor over the desire for timely risk reduction. The underlying assumption for needing a contingency is that the ability to ship waste offsite has been impacted. The net result of this is a decision to either do nothing, i.e. no action, in which case timely risk reduction cannot occur, or to implement an on-site storage CAMU.

The final design alternative comparison used the RFCA criteria, as discussed in Section 6, to select the best alternative.

6.0 COMPARISON OF SCREENED ALTERNATIVES

The four alternatives discussed below are all based on the scenario that assumptions used to generate the schedules for risk reduction in the Ten Year Plan become invalid. In other words, in the event that waste generation, storage, or shipment assumptions, relative to offsite shipment of remediation waste as it is generated, in the Ten Year Plan become invalid, one of these four alternatives would be necessary to ensure that risk reduction activities and site closure at RFETS remain on schedule. Any alternative used for storage at RFETS would be an interim action that would eventually require resources for offsite disposal. The value of these interim action alternatives is to serve as a contingency to ensure that risk reduction activities such as source removals and building D&D would be implemented in a timely fashion consistent with the overall site strategy for closure.

Based on the analysis presented in this decision document, bulk placement of the remediation waste in the Concrete-lined Cell at the site east of the Solar Pond was the remedy selected for management of remediation waste. The abovegrade Concrete-lined Cell with bulk placement was selected from the four final alternatives screened in Section 5.0:

- No Action Alternative (Defined as utilizing current waste management resources and facilities recognizing Ten Year Plan assumptions would not be supported)
- Abovegrade Storage Cell
- Abovegrade Concrete-lined Cell with bulk placement
- Metal Buildings

These four design alternatives were compared using the seven RFCA criteria from Paragraph 109a (DOE, 1996a) to select the best alternative for remediation waste management at RFETS. The seven RFCA criteria are as follows:

1. Worker Safety
2. Protection of Public Health and the Environment
3. Transportation
4. Facility Design, Containment and Monitoring
5. Institutional Controls
6. Cost
7. Community Acceptance

Two other criteria have been included that address NEPA values:

- Short-Term Effectiveness
- Long-Term Effectiveness and Permanence

A summary of the final comparison of the four screened Alternatives is provided in Table 6-1. Statements concerning public acceptance serve as placeholders and would be modified based on public input as the review cycle progresses.

Table 6-1 Summary of the Final Alternative Comparison for a Remediation Waste Storage Facility

	RFCA Criteria	RFCA Criteria	RFCA Criteria	RFCA Criteria	RFCA Criteria
Final Design Alternative	**Worker Safety**	**Protection of Public Health and the Environment**	**Transportation**	**Facility Design, Containment and Monitoring**	**Institutional Controls**
Abovegrade Storage Cell	Risks to workers are similar for all alternatives considered. Spraying of water during construction would reduce exposure to dust. Location is in a low traffic area.	RCRA double liner system provides groundwater protection. Leakage would be detected in the liner system. Bulk storage offers less control of fugitive dust emissions during waste transport and placement.	Centralized location minimizes transportation requirements onsite. Design and location should have minimal impact on existing traffic patterns.	Liner system provides additional containment plus the ability to detect leaching. Air monitoring could be performed in conjunction with existing RFETS monitoring.	The RFCA acts as an institutional control requiring continued maintenance of the facility. Since the use of the facility is for short-term storage, controls beyond those inherent in RFCA are not necessary.
Concrete-lined Cell with Bulk Placement	Risks to workers is similar for all alternatives considered. Spraying of water during construction would reduce exposure to dust. Location is in a low traffic area.	RCRA double liner system provides groundwater protection. Concrete walls and floor provide additional protection. Leakage can be detected and collected prior to reaching liner system. Bulk storage offers less control of fugitive dust emissions during waste transport and placement.	Centralized location minimizes transportation requirements onsite. Design and location should have minimal impact on existing traffic patterns.	Leachate would be detected and collected in a cell collection system prior to reaching the subsurface liner. Air monitoring would be performed in conjunction with existing RFETS monitoring.	The RFCA acts as an institutional control requiring continued maintenance of the facility. Since the use of the facility is for short-term storage, then controls beyond those inherent in RFCA are not necessary.
Metal Buildings	Risks to workers is similar for all alternatives considered. Spraying of water during construction would reduce exposure to dust. Location is in a low traffic area.	Containerized waste and building reduces exposure to the workers and the public. Visual inspections allow leaks to be detected before release to the environment. Most control of fugitive dust emissions.	Centralized location minimizes transportation requirements onsite. Design and location should have minimal impact on existing traffic patterns.	Waste would be in containers which would be more easily monitored visually. Air monitoring would be performed in conjunction with existing RFETS monitoring.	The RFCA acts as an institutional control requiring continued maintenance of the facility. Since the use of the facility is for short-term storage, then controls beyond those inherent in RFCA are not necessary.
No Action Alternative	Increased risk of exposure due to less containment (sources exposed).	Less protective due to no containment . Sources could remain exposed to the environment for a longer period.	. Current RFETS storage capacity would not support Ten Year Plan risk reduction schedules.	Additional inspection due to unconsolidated sources. Less containment.	Current RFETS institutional controls apply.

Table 6-1 (continued)

	RFCA Criteria	RFCA Criteria	NEPA Evaluation	NEPA Evaluation
Final Design Alternatives	**Cost**[1]	**Community Acceptance**	**Short-Term Effectiveness**	**Long-Term Effectiveness and Permanence**
Abovegrade Storage Cell	This storage alternative has a high total cost of **$119M** plus cost of offsite disposal and requires a large footprint for the total facility.	Monitoring and retrieving the waste is more difficult with this option.	Reduces waste handling requirements for accelerated actions and D&D projects. Focuses resources on risk reduction. Design less flexible. than other alternatives.	Provides sufficient permanence for an interim solution. Utilizes natural non-degradable materials in cap and liner design to support intended operational life. .
Concrete-lined Cell With Bulk Placement	This storage alternative has a total cost of **$77M** plus cost of offsite disposal. The cost benefit outweighs other alternatives and allows more resources to be applied to risk reduction rather than waste management. Option offers an ability to monitor and retrieve waste at a relatively low cost.	This alternative offers monitoring and retrievability of the remediation waste but physical inspection is not to the degree that metal buildings would offer.	Reduces waste handling requirements for accelerated actions and D&D projects. Modular design allows for rapid construction. Focuses resources on risk reduction.	Provides sufficient permanence for an interim solution. Utilizes natural non-degradable materials in cap and liner design to support intended operational life.
Metal Buildings	This storage alternative has a cost of **$161M** plus cost of offsite disposal, not including the additional lost for the liner system required in RFCA. The high cost is the result of the container costs.	This alternative combines easy monitoring and retrievability with offsite disposal. Visual leak inspection is possible. Protectiveness is less than other onsite options.	Additional packaging requirements needed to containerize waste. Rapid construction would speed up availability of facility. Not as suitable for volumes >100K yd	Provides sufficient permanence for an interim solution The buildings themselves are not as effective for the long-term due to high maintenance. Not very reasonable for volumes >100K cy yd
No Action Alternative	Most cost effective alternative. Only offsite disposal costs would apply. Minimal additional inspection or monitoring costs may be required due to delayed source removals.	Waste would be sent offsite on a schedule not consistent with the Ten Year Plan. Risk reduction schedules would increase.	Ability to store on site may delay risk reduction.	All offsite disposal facilities under consideration have been designed for long-term use. Not effective if source removal delayed.

1. Cost estimates do not include offsite shipment and disposal which is deferred until closure of the RWSF.

Worker Safety - Each of the Alternatives posed standard industrial risks to workers. All of the Alternatives would be labor intensive to implement but would not pose any unusual risks. Air monitoring, spraying to minimize dust, and the use of a daily cover would protect plant workers from airborne contaminants during construction and operations. Once constructed, the onsite Alternatives would pose minimal risk to RFETS' workers because engineered barriers would contain the remediation waste. In addition, the selected site is in an area of minimal traffic. The No Action alternative could require that sources remain exposed to the environment, increasing risk.

Protection of Human Health and the Environment - In terms of design, the Concrete-Lined Cell with bulk placement had the most protective design elements. The leachate collection system in the concrete floor of the cell would have a significant advantage. Unlike the above-grade storage cell, contaminants could be detected and captured within the cell. In the above-grade storage cell design, the contaminants would be captured in the first or second layer of liners. The Metal Building alternative could also contain the leakage in the structure or in a liner system.

The No Action alternative would immediately have to rely on an offsite facility to provide protection. Unfortunately, because this alternative would provide less immediate source removal, the overall RFETS protectiveness would decrease since risk reduction could not occur as scheduled. It was assumed that a permitted offsite disposal facility would afford adequate protectiveness once the waste is placed. The additional time necessary to achieve risk reduction due to waste volume, storage, or shipment restrictions would increase risk to human health and the environment. This would result in more contaminant sources remaining exposed in the environment and could actually increase the risk to human health and the environment.

All of the Alternatives would offer protection from erosion. Likewise, there would be little difference among the Alternatives in terms of biological impacts since these impacts were expected to be minimal.

Transportation - The central location of the RWSF would minimize onsite transportation of remediation waste. In addition, the location is in a low traffic area. The eventual shipment offsite, however, would require additional transportation either by truck or by rail. For all of the alternatives, upgrades to RFETS shipping and transportation facilities would be necessary.

Facility Design, Containment and Monitoring - All of the onsite Alternatives would have features to provide additional containment and monitoring. The Concrete-lined Cell with bulk placement would have the best physical containment because both the cells and the liners have a leachate collection system. The Metal Building alternative would offer the ability to visually monitor the waste, plus the waste and the containerized waste could be easily retrieved for shipment. This design was not, however, as conducive to extremely large volumes of bulk storage. The Abovegrade Storage Cell would not offer the same degree of monitoring or containment as the two other onsite options. The No Action alternative would require additional resources for inspection of remediation wastes awaiting shipment and disposal.

Institutional Controls - The selected location in the Solar Ponds Area combined with RFCA would act as an institutional control since the DOE must comply with paragraph 278 of RFCA which would require continued maintenance of a containment system in the event that the property is leased or the title is conveyed to another party. Because the RWSF would only be operational as long as operations were continued in the Industrial area, additional institutional controls beyond the existing controls were not deemed necessary. For the No Action alternative, institutional controls of some form would likely exist; for offsite facilities, however, DOE and CDPHE involvement in those controls could be minimal.

Cost - Based on near-term costs, the concrete-lined cell would be the least expensive interim alternative ($77,300,000). The Abovegrade Storage Cell would be more expensive ($118,800,000) than the concrete-lined cell because its footprint would be bigger and would require more site preparation and fill material. The cost of the Metal Buildings ($161,400,000) was also greater than the cost of the concrete-lined cell because it would require containers and would have a larger footprint.

The costs for each alternative are listed in Table 6-1. A more complete breakdown of costs are in the alternative descriptions in Appendix E and in the backup for the facility design screen in Appendix F. None of the cost estimates (except No Action) included offsite disposal which was assumed to be deferred until the waste could be removed from storage.

Community Acceptance - The no action alternative would delay risk reduction and therefore was deemed least acceptable. Because only temporary storage of the waste is being proposed, ultimately there must be some community impact with any of the options. Of the three onsite options, the metal buildings would likely be the most acceptable option to the public since this alternative would offer the ability to inspect the waste in containers and to easily retrieve the containers for offsite shipment. Furthermore, since metal buildings would have a limited useful life, the community might find this a more acceptable alternative since it would have a limited ability to provide long-term storage. All of the alternatives would have the ability to monitor and retrieve the stored waste. The ease of retrieval varies between alternatives.

Short-Term Effectiveness - Because only temporary storage is being considered, the relative importance of this criterion was elevated. Particular emphasis would need to be placed on supporting an accelerated cleanup of RFETS as described by the Ten Year Plan and RFCA. This would support overall risk reduction recognizing that overall costs would increase relative to offsite disposal without the need for storage.

The other issue of short-term effectiveness was logistics. In the event Ten Year Plan assumptions fail, short-term effectiveness relative to the ability to implement timely risk reduction at RFETS would be limited until a facility was available to handle large volumes of remediation waste.. An Abovegrade Storage Cell and the Concrete-lined Cell would allow bulk waste to be placed in the facility without additional containerization, and onsite transportation requirements would be minimal.

Because of convenience and initial cost, the Abovegrade Storage Cell and the Concrete-Lined Cell would best support the implementation of D&D and Environmental Restoration actions if waste volumes significantly exceed projected estimates. The Metal Building alternative would require some additional packaging effort and the No-Action alternative would require additional preliminary efforts to both package and transport the waste; however; all of the alternatives would require these actions for eventual offsite shipment.

Long-Term Effectiveness and Permanence - Since at the closure of the RWSF all of the waste would be shipped offsite for disposal, the long-term ability of any alternative would be dependent on the offsite disposal facility selected. However, the relative permanence and long-term effectiveness of the selected alternative would be important because they would generally be indicative of the facility's protectiveness.

Of the four onsite alternatives, the Concrete-Lined Cell with bulk waste placement would have the greatest degree of long-term effectiveness and permanence based on the extra protection offered by the 12-inch-thick concrete walls and 18-inch-thick floor. The internal concrete structure would add both an additional barrier to leakage as well as internal structural support for the facility.

The No-Action alternative and the Abovegrade Storage Cell would also offer good long-term effectiveness and permanence relative to the overall operational term of up to 25 years. The Abovegrade Storage Cell would offer about the same degree of permanence as the concrete-lined cell because it would utilize a similar liner system and contoured cover. However, the Abovegrade Storage would not have the additional protection of the concrete infrastructure of the concrete-lined cell nor would it facilitate regular retrieval for offsite shipment as effectively. The Metal Building alternative would offer the least amount of long-term effectiveness and permanence for the volumes estimated (up to 300,00 cubic yards). Since the facility would only be intended for temporary storage this translates into only limited flexibility.

The Concrete-Lined Cell was selected because of the following criteria:

- It would be protective of the environment and human health. The engineered features would provide additional protection that the other alternatives do not have such as a multiple layer cover and an 18-inch concrete floor with its own leachate collection system.

- It would provide more flexibility in storage options since it could accommodate either bulk storage or containers and would be suitable for volumes from a minimum of 33,000 cu yd to 300,000 cu yds.. It would also offer the retrievability and segregation capabilities needed for short-term storage and shipping operations combined with the protectiveness of a more permanent facility.

- It would best support environmental restoration and D&D activities since large volumes of bulk waste could go from treatment or excavation right into the facility. In the near-term, it would cost less than the No-Action alternative and, therefore, would free up funding for additional mortgage reduction activities and accelerated environmental actions. Finally, it would be the least costly of the onsite alternatives.

- It could be easily expanded. Because this alternative would be installed in a modular fashion, additional cells could be built adjacent to the original cell if needed. The use of modules would allow one module to be filled while another is being constructed. This would create flexibility for future waste management decisions while not committing funds until necessary. Finally, this modular design would conform well to the Ten Year Plan and RFCA as well as plans for the future use of RFETS.

Prior to initiation of any CAMU alternative the objectives for the facility will be closely scrutinized to ensure that the most efficient and cost effective design is selected. This evaluation will include waste types, waste volumes, and current offsite shipping capabilities. The factors, along with others will greatly influence the appropriateness of the design to meet site closure objectives.

7.0 SELECTED REMEDY

Section 7.1 describes the selected alternative and gives more detail of how the alternative meets the objectives of the IM/IRA, the RFCA, and the CAMU criteria. The basis for the selection of the specific alternative is described in Section 7.2, with a discussion of how the selected alternative meets the objectives of the IM/IRA that were outlined in Section 1. A Risk Evaluation is provided in Section 7.3 which discusses studies that were performed to assure that the RWSF would meet design and monitoring requirements included in RFCA and in the CAMU rule. Section 7.4 discusses technical and administrative controls for the CAMU that would meet the requirements identified in RFCA paragraph 80. Discussion of how NEPA values were addressed throughout the document is included in Section 7.5. Conceptual waste acceptance criteria (WAC) are described in Section 7.6. Section 7.7 discusses operational controls and plans that would control the activities and waste operations of the RWSF.

7.1 REMEDY DESCRIPTION

7.1.1 General Description for Cost Estimating

The selected alternative, the Concrete-lined Cell, would consist of a series of modular cells, each sized for approximately 33,000 cu yd of waste with the ability to expand up to 300,000 cu yd, as appropriate, to meet storage needs. The concrete-lined cell would be located immediately east of the Solar Ponds in the northeast quadrant of the Protected Area. (See Figure 7-1). This facility would be placed abovegrade with the lowest point of the leak detection system also being abovegrade. The RWSF would be designed with a double composite liner system with modular concrete cells which meet the requirements of 6 CCR 1007-3, Part 264, Subpart N (See Figures 7-2 and 7-3.) A cover would isolate wastes from infiltration and erosion. An example of a type of cover is included in Figure 7-3. The liner would comply with RCRA Subtitle "C" requirements as defined in 6 CCR 1007-3, Part 264. For the purpose of cost estimating, the conceptual design currently incorporates the following features:

- Self-supporting reinforced concrete structure;
- A facility size of 500 ft long by 360 ft wide and 14 ft deep (approximately 4.13 acres);
- Up to three modules, each 500 ft long by 120 ft wide further divided into compartments for waste segregation in bulk or cargo containers;
- A reinforced concrete slab with cast-in-place drain channels and sumps, designed to minimize clogging, for leachate collection;
- External and internal reinforced concrete walls and slab with integral waterstops and leachate stops;
- A double liner system including one primary liner, one composite secondary liner, and a leachate detection/collection system;
- An operational cover to enclose the cell/module during operations for fugitive dust controls and to reduce the generation of leachate;

- A earthen cover system to be placed after filling the cell which would slope at a 3% grade over the top of the waste with steeper slopes on the sides of the facility. Other cover designs are identified in Appendix B-2

- Five monitoring wells for groundwater monitoring; and

- A leachate transfer and storage system.

The leachate transfer and storage system would be provided to manage leachate that would be collected in the RWSF. Leachate would be transferred from the RWSF to a treatment system, as necessary. The collection system will be designed to minimize clogging. A separation layer will be placed between the gravel in the leachate collection system and the floor slab to prevent concrete from filling the interstitial volume in the gravel. This separation layer will be made out of a chemically resistant material as required by 6 CCR 1007-3, Part 264, Subpart N.

Groundwater monitoring would be done in accordance with all applicable rules and regulations, including, but not limited to, CAMU requirements in 6 CCR 1007-3, Section 264, Subpart S. A groundwater monitoring plan would be prepared and submitted during the design review process. Groundwater monitoring for this facility will be integrated with the RFETS sitewide Integrated Monitoring Plan.

During operations, an operational enclosure (a sprung structure) would cover the cell/module to minimize fugitive dust and reduce the infiltration and generation of leachate until the cover is completed. Waste would be placed in the facility in bulk or in containers. In addition, this facility would allow for the options of placing waste in cargo containers or segregating wastes.

Once a module/cell had reached capacity with remediation wastes, a cover such as earthen or metal would be constructed and the temporary sprung structure would be removed. The cover would impervious and sloped to promote drainage. This cover would be removed when the waste is ready for offsite disposal.

7.1.2 Additional Cover Alternatives

Although the earthen cover was used for cost estimating purposes, additional cover designs have been identified. The final design phase will support final cover selection. Other cover design alternatives include:

• Metal Roof Deck - This option is similar in design to a standard metal "butler" type building roof. Baked enamel steel deck would be fasted to steel joists spanning individual modules with drainage channels between the module roofs. This design may also support the objectives of an operational cover.

• Precast Concrete Panels - This option utilizes twin-tee precast concrete panels to span the module width. A urethane or similar cover would be placed over the concrete panels to provide an impermeable barrier.

Both options may require different wall and slab thicknesses than the specifications used to develop the cost estimate for the earthen cover. Additional column supports within the module may also be required. The selection of the cover during the design phase will also include an evaluation of the necessity for an alternate cover design for the operational cover. This may reduce overall costs by having a single cover design that supports both operations as well as storage.

7.2 DECISION BASIS

A concrete-lined cell in the Solar Ponds Area was selected and justified based on the screening criteria and the final comparison criteria presented in Sections 5 and 6 of this Decision Document. To further support that selection, this section provides an evaluation of the selected remedy in terms of the original objectives of this document as presented in Section 1.0. Section 7.2.2 summarizes the value engineering study performed and the basic benefits of the selected remedy.

7.2.1 Objectives

As stated in Section 1.1.1, there are four main objectives of this IM/IRA. The selected remedy meets those objectives in the following manner:

1. **In support of the RFCA and the Ten Year Plan, the management of low-level, low-level mixed and hazardous remediation waste must ensure the safety of the public, RFETS workers, and the environment through reliable, effective, protective, and cost-effective management of remediation wastes at RFETS. The waste shall be stored in a readily retrievable configuration.**

The selected remedy addresses this objective through the following safety features:

- All work including construction, filling operations, handling, and transportation would be done under an approved health and safety plan (HASP).
- The remediation waste that would be placed in this facility would generally have very low levels of radionuclides. Low-level and low-level mixed wastes are limited to activities of less than 100 nCi/g. For example, samples taken from beneath the 903 Pad have ranged as high as 20 nCi/g but this will probably include less than 20% of the 903 Pad total volume to be remediated. Much lower levels are anticipated for the remainder of the soils at the 903 Pad. Current RFCA Tier I cleanup levels for soils are less than 1 nCi/g. The majority of the soils are anticipated to be closer to the lower level of concentration.
- Work would be performed under the oversight of industrial hygienists, occupational safety professionals, and radiological engineers.
- Workers would be required to undergo extensive training based on the specific hazards of their job.

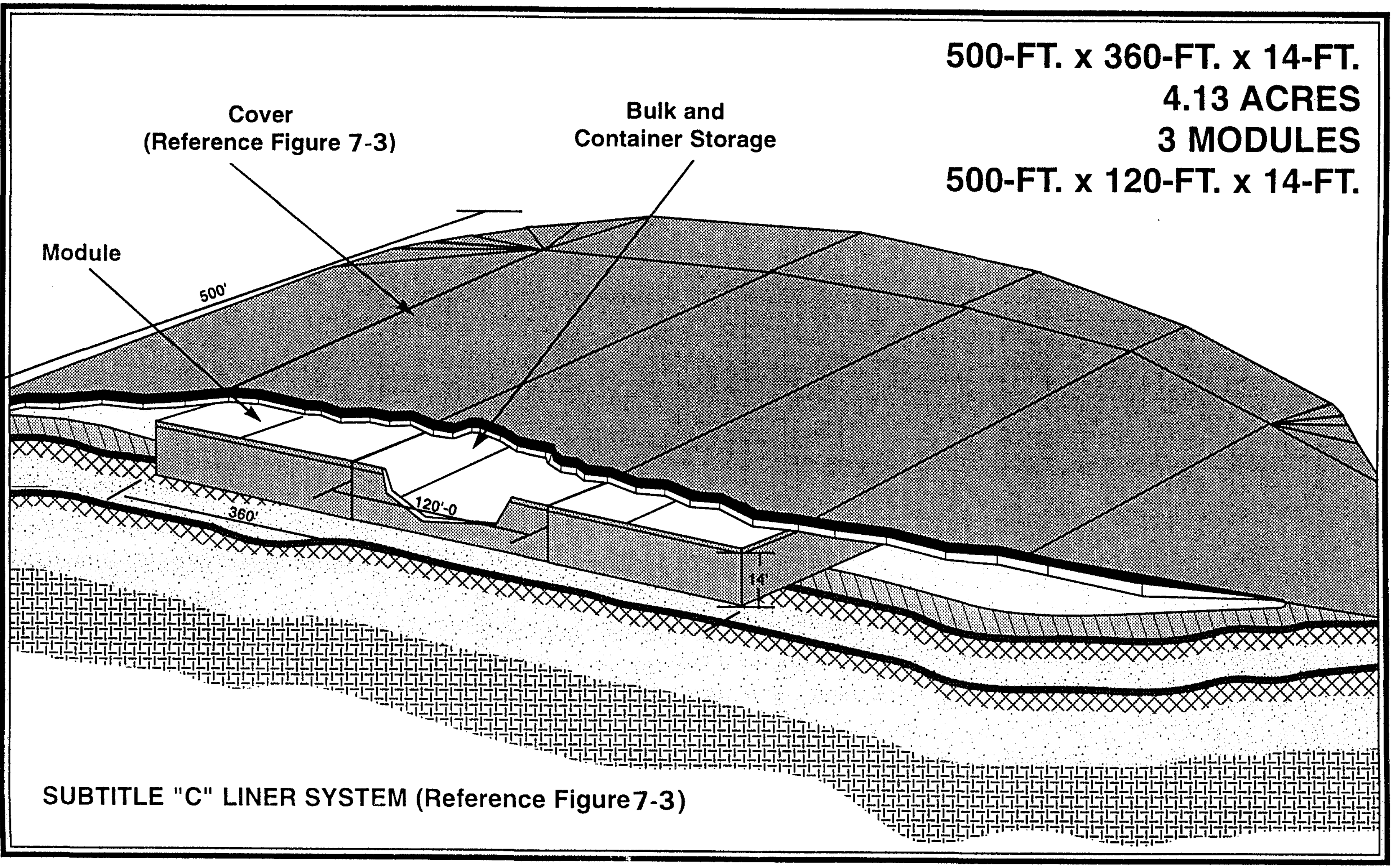


Figure 7-2

CONCRETE-LINED CELL WITH BULK WASTE PLACEMENT

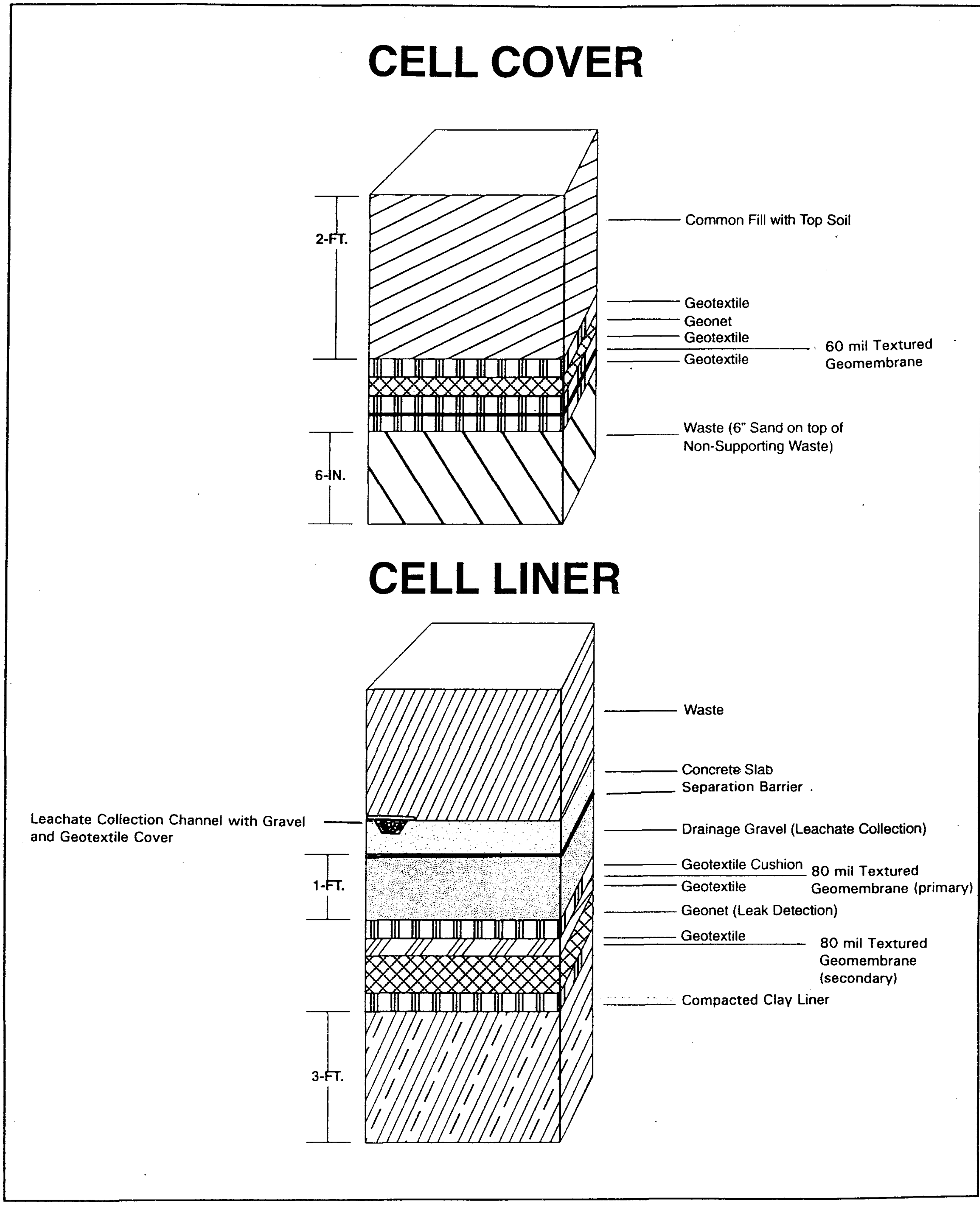


Figure 7-3

ON-SITE FACILITY CROSS SECTION

- A wide range of dust suppression measures would be taken during construction, transportation, handling, and filling operations to ensure that fugitive emissions of vapors or particulates were not generated. Dust control activities during handling, transportation, construction, and placement could include an operational cover, dust suppression sprays, high wind shut-downs, or other precautions.

- Various types of monitoring would be performed to ensure not only the safety of the public and RFETS workers but also the protection of the environment. This would potentially include air monitoring for particulates and contaminants, radiological monitoring, ground water monitoring, and surface water monitoring.

- Once a module or cell was filled, a protective cover would be placed over it.

The facility has numerous design features added to ensure protection of human health and the environment. Some of these protective measures are as follows:

- An impermeable cover to minimize infiltration of water to reduce the generation of leachate and soil erosion (if applicable) if offsite disposal is not readily available;

- A reinforced concrete slab floor;

- Waste separation through the use of compartments built into the modular design;

- Reinforced concrete walls;

- Two leachate collection/detection systems, one system to be built into the floor of the facility; the second system to be built into the liner system;

- A multiple-layer liner system that utilizes both synthetic and natural materials; and

- A groundwater monitoring system.

Design and administrative features that support retrievability/storage:

- An above grade design;

- A modular design allowing enhanced waste segregation and easier retrieval;

- A temporary cover to be designed to support retrievability; and

- A twenty five year operational life span limit detailed in the CAMU application

2) **The solution must support a flexible waste management policy combining contingencies for both long-term storage and shorter-term staging/storage for offsite disposal while recognizing the uncertainties associated with current waste volume estimates and future offsite disposal availability. A flexible policy would ensure that the most timely and cost-effective strategy that supports RFCA and TYP objectives can be developed.**

The selected alternative would support a flexible waste management policy by serving as a bulk storage facility in the event that remediation waste must be stored onsite for an extended duration.

This CAMU would compliment another CAMU designation for a storage facility to hold containerized waste since this would cover a full spectrum of contingencies. A storage facility for containers could meet the need for staging, handling, and short-term storage, whereas the RWSF would be needed if the waste had to be stored for long period or if the volume of waste was so large that a metal building would be impractical. In addition, the RWSF would support a flexible waste management policy as follows:

- The RWSF would be able to accept both containerized and bulk waste.
- The RWSF would have a small footprint that would allow more waste to be stored in a single area.
- The RWSF would use a modular design that would allow the facility to be adjusted for varying waste volumes and waste types. The facility could be adjusted to the influx of remediation waste.
- The RWSF could segregate and isolate different waste types.
- Future modules could have customized containment and monitoring features.

3) The management of low-level, low-level mixed, and hazardous remediation waste must result in a cost-effective solution.

If storage is needed, the Concrete-lined Cell would be the most cost-effective of the alternatives considered that could meet RFCA criteria. Table 7-1 gives the total life cycle costs for all of the design alternatives considered.

Table 7-1 Life Cycle Costs for Design Alternatives

Alternative	Total Life Cycle Cost
Abovegrade Storage Cell	$119,200,000
Pyramid	$141,800,000
Concrete-lined Cell with bulk placement	**$79,120,000**
Concrete-lined Cell with containers	$167,450,000
Hardened Concrete Vault	$185,130,000
Silo Design	$114,300,000
Slab on Grade	$143,400,000
Metal Buildings	$164,000,000
Entombment	$533,800,000
Waste Pile	$36.969,000
No Action	$0

Based on professional judgment, the cost differences between location alternatives were not as significant as cost differences between the design alternatives.

In terms of cost, the CAMU should still be a contingency to the assumption of immediate offsite disposal in the Ten Year Plan in case additional storage is needed for large volumes of remediation waste. The No Action alternative for shipping remediation waste offsite offers the lowest life-cycle cost but delays risk reduction. Cost issues would have to be balanced against risk reduction capability when determining if the CAMU should be implemented.

4) A means of consolidating remediation waste in one location is needed to support near-term risk reduction goals while addressing long-term liability and safety issues.

The location and design were selected to allow large quantities of remediation waste to be consolidated at a single location. Not only does the location and design allow the physical consolidation of the waste but it also allows waste management activities such as operations, monitoring, and inspection to be consolidated as well.

The selection of a Concrete-lined Cell in the Solar Ponds Area would be consistent with future land use described in the preamble to the RFCA. The ways that the selected alternative supports the Site Vision and reasonably foreseeable future land uses are as follows:

- The RWSF would be a storage facility which would be consistent with the Site Vision goal of dispositioning remedial waste in a safe manner.
- The site selected is in the Industrial Area of RFETS and could potentially extend over several IHSSs. Reasonably foreseeable future land use for this area would be for limited industrial use. The area near the Solar Ponds would be far enough away from any building that might be reused so as not to impact any future RFETS activities.
- The design and centrally located site would facilitate monitoring and maintenance. Monitoring could be performed in conjunction with monitoring activities already required for the industrial area. Existing air monitoring systems could also support monitoring for the RWSF.

7.2.2 Summary of the Value Engineering Study and Selected Remedy Benefits

As part of the effort to define the design concept for the RWSF and in accordance with DOE Order 4010.1a, a value engineering study was performed. In the value engineering analysis method, multiple alternative approaches of accomplishing the project functions were subjected to qualitative and quantitative techniques to determine the value of each. The alternative which represents the highest value was selected for further development.

Four categories of protective elements, elements that were considered essential components of any acceptable design and that represent the highest costs of implementability and operation of the facility, were selected for inclusion in the value engineering study:

- Protective barriers at the bottom of the facility (liners and/or other structures)
- Protective barriers at the top of the facility (cover and/or other structures)
- Waste placement
- Waste removal (exhumation at end of storage period)

Many combinations of construction and placement were identified that could accomplish the functions associated with the four categories. An application of the value engineering techniques identified a design incorporating a concrete structure, conventional liners, and a cover. Waste would be placed in bulk (rather than in individual containers) to represent the highest value. The results of the value engineering study independently validated the selection—of the Concrete-lined Cell with bulk storage—attained through the alternatives analysis process.

To support the selection of a Concrete-lined Cell at the Solar Ponds Area, the following advantages are cited:

- The modular design offers the greatest degree of flexibility including the following attributes:

  — A wide variety of waste types could be accepted and kept segregated

  — Debris could be placed in the facility without additional characterization, compaction, or size reduction

  — The facility could be expanded as needed to meet the needs of cleanup at RFETS as the cleanup progresses

  — The RWSF could accept both bulk and containerized wastes

  — The RWSF could store waste for varying durations

- The facility would have a high degree of protectiveness because of the concrete containment system, the liner system, and the cover. All of these features offer much greater protection than would be found in a typical storage facility.

- One major advantage would be that the concrete containment system would allow for the capture of contaminants before they reach the subsurface rather than depending on the liner system. Media below the facility would not be contaminated should leaching occur. The liner system would act only as additional back up barriers or as tertiary containment, rather than as the secondary containment system.

- The facility would be situated in an area where contamination is already present.

- The selected location had strong CDPHE support based on previous input.

- The facility would be centrally located to many of the IHSSs that need remediation.

- The RWSF would minimize indirect effects on the environment its location in the Industrial Area where existing infrastructure would support the use of the facility.

Because the RWSF would be built on an existing facility in an area previously contaminated, it would not disturb additional areas on RFETS and it would minimize cumulative effects on the environment.

In selecting a design for the RWSF, emphasis was placed on flexibility and environmental protection. In part the design was selected because it could safely contain remediation waste for any period of time necessary. If the waste could not be removed in a reasonable amount of time, then the facility would have to be durable enough to ensure the protection of human health and the environment until the waste could be removed within the 25 year operational time frame. An added benefit of using this facility for long-term storage is that it could allow the time needed to develop new treatment technologies or alternative offsite disposal sites.

7.3 RISK EVALUATION

A number of studies have been conducted to provide assurance that the recommended alternative would meet the established criteria for the RWSF. These analyses were conducted to support CAMU criteria for protection of public health and the environment as listed in 6-CCR-1007-3 Part 264.552 (c). The analysis of risk was divided into the following three main exposure pathways:

- Offsite transport of contaminants through the groundwater to neighboring surface waters
- Worker exposure to radionuclides during operations
- Offsite fugitive dust emissions

The potential for vertical contaminant migration through underlying geologic strata into the Laramie-Fox Hills aquifer was previously addressed and was considered to be an unrealistic scenario (RMRS, 1996). The most conservative calculations of volatile organic contaminant transport indicated that travel times of at least 17,000 yr would be required for contaminants to migrate to the deep aquifer, which greatly exceeds the 1,000 yr time-frame considered in this document. The analyses performed in this report confirmed the conclusions reached by the U.S. Geological Survey (Hurr, 1976) that plant operations would not impact this aquifer. More information on potential contaminant migration to the Laramie-Fox Hills aquifer is contained within the "White Paper Analysis of Vertical Contaminant Migration Potential" (RMRS, 1996).

Exposures from inadvertent intrusion into the RWSF after closure were also ruled out primarily because waste would be actively managed and shipped offsite for disposal. In addition inspections and monitoring throughout the life of the facility would occur as per RFCA paragraph 80. As long as wastes remain on-site in the protected area (PA) and the site was on the CERCLA National Priorities List (NPL), administrative controls would be required to limit access onto the site and five-year public health reviews would be required to ensure that the remedies used remained protective as long as waste remained onsite. It is also assumed that a fully integrated sitewide monitoring network would remain in effect to detect any releases from this action or any other as long as any waste remained on site.

In addition to the pathways analyses referenced above, an analysis of technical and administrative controls were included. These controls are the administrative, design, operational, and post closure practices put in place to ensure releases are prevented or are prevented from impacting human health and the environment. Institutional controls could include deed restrictions, interagency agreements, and other controls.

Analysis of risks to public safety during transport to offsite disposal was not performed since this activity will occur independent of any decision to implement a CAMU.

7.3.1 Offsite transport of contaminants through the groundwater to neighboring surface waters

As with most waste management systems, potential accidental offsite releases to the public or the environment constitute the majority of risk. Siting criteria, design requirements, and facility monitoring requirements were all established to mitigate the likelihood of a release event occurring. Several studies relative to the location of the RWSF, as well as the design itself, were conducted to assess the likelihood of a release and the resulting level of contamination associated with such an event. One of the pathways considered was a release of contamination from the facility to groundwater and the subsequent transport of contamination to surface waters, where exposures to the environment or the public could occur. Three integrated studies were conducted to assess what, if any, risks might result from such a release:

- Remediation Waste Storage Facility (RWSF) Particle Tracking Study
- Leachate Composition Analysis
- Discharge Composition Analysis

The first two studies identified the primary parameters for an exposure to occur, travel times, and source concentrations of contaminants. The final study defined the overall estimated concentrations based upon infiltration through various cover designs. These studies are attached to the decision document as Appendix G and are summarized below.

7.3.1.1 Remediation Waste Storage Facility Particle Tracking Model

The particle tracking study used a site-validated mathematical model to track contaminant flow through the groundwater beneath the RWSF and estimated travel times to neighboring surface waters. Travel times were based upon varying retardation factors for a particle in contaminant categories that include metals, organic compounds, and radionuclides Retardation factors were based upon solubility, adsorption coefficients, and other factors that influence a contaminant's ability to flow freely within the groundwater. The retardation factors were either obtained from literature values or from RFETS-specific values. The time frames considered for transport were 30 yr, 500 yr, 1,000 yr, and 10,000 yr. The times used all exceeded the estimated 25 year operational life of the storage facility. The intent of the facility would be to support site closure by providing a facility for storage only. Travel times did not assume any engineered barriers at the top or the base of the RWSF. These times were extremely conservative due to the assumption of no engineered barriers and represented a worse case scenario. In addition to the conservative travel times, the study made no representation as to what levels of contaminants would reach neighboring surface waters within these time frames but was strictly limited to the travel time for a particle of material.

Metals and radionuclides have extremely high coefficients of adsorption, meaning that metals and radionuclides tend to adhere to clays within the surrounding soils and, therefore, exhibit limited movement. In addition, clay liner systems within the RWSF would further limit migration. The particle tracking models showed that migration would be limited for periods of nearly 1,000 years. Given the engineered barriers designed for the RWSF and the limited operational life cycle, discharges to surface waters were not expected. In addition, given the levels of metals and radionuclides associated with the estimated leachate composition and the estimated infiltration rates into the RWSF, no contaminant levels above stream standards were anticipated within the unit boundary.

Organic compounds present the predominant risk for completing the pathway to neighboring surface waters. The particle tracking model predicted that organics could conceivably reach surface waters within 100 yr without the engineered caps and liner systems designed for the RWSF. Organics levels however, were expected to be very low since thermal desorption technology is currently being used to treat soils and debris prior to disposition into a storage facility. Given the anticipated levels of organics within the leachate, the levels of organics discharged to surface waters if a potential release occurred, would be significantly less than what would be allowable to protect human health or the environment and would meet RFCA Action Levels and standards for water. The leak detection system of the liners would signal an alarm before a potential release to the groundwater or surface waters occurred. These results are detailed in the leachate composition analysis and waste composition analysis.

7.3.1.2 Leachate Composition Analysis

This analysis identified an estimated leachate composition that was statistically based upon actual analytical results for areas at RFETS which were considered possible candidate sites for which materials could be placed into the RWSF. Multiple waste streams were used to ensure that the analysis was based upon a representative sample of likely contaminants for RFETS. This analysis considered organics, metals, and radionuclide concentrations (see Table 1, Appendix G, p21).

7.3.1.3 Discharge Composition Analysis

The maximum contaminant concentrations that may occur in groundwater from a potential release from the RWSF were calculated. These calculations were performed on the basis of estimated concentrations of contaminants from the leachate composition analysis and the estimated volumes of leachate anticipated to be generated as a result of moisture infiltration into the RWSF through the cover. Two cover scenarios were evaluated, one design was quite robust while the other design is less extensive . The intent of this analysis was to provide a benchmark for estimating maximum potential values of contaminant discharge via groundwater into neighboring surface waters from the RWSF. This study assumed that no leachate collection was included in the RWSF design. However, both a leachate collection system and liner were designed to capture any discharges from the RWSF eliminating contaminant transport to the groundwater. The discharge composition analysis study represented a worst case scenario where the leachate collection system was inoperable. This did not assume a catastrophic breach however, only a failed collection system where leachate was allowed to accumulate within the liner system and eventually discharge through the liners into the groundwater. Since this facility will be actively managed throughout the 25 year operational life, neither scenario is likely. These flow rates were based upon infiltration rates calculated with the HELP model, an EPA approved model for evaluation of engineered barriers (EPA, 1985).

Based upon an estimated waste stream leachate analysis, no discharges to surface waters above action levels were anticipated for either cover scenario. A detailed table listing estimated discharge levels for specific contaminants is included in the study (see Table 3, Appendix G).

7.3.2 Worker Exposure to Radionuclides During Operations

A radiological dose assessment was conducted to assess the maximum radionuclide activities allowable in soils at the RWSF, based on annual exposure limits. The dose assessment used an upper annual exposure limit for a worker of 5,000 mrem/yr (10 CFR 834), and a lower limit of 100 mrem/yr (DOE Order 5400.5). The exposure scenario was for a RWSF operational worker and used site-specific exposure factors. (See Programmatic Risk-Based Preliminary Remediation Goals, Rev 2, DOE 1995).

The soil activity for each individual radionuclide necessary to give a 5,000 mrem annual dose to a worker at the RWSF is 64,100 pCi/g of americium-241, 74,900 pCi/g of plutonium-239, and 1,020,000 pCi/g of uranium-238. The activity of each radionuclide to deliver a 100 mrem annual dose is 1,280 pCi/g for americium-239, 1,500 pCi/g for plutonium-239, and 20,400 pCi/g for uranium 238. These activities were calculated separately for each radionuclide. If all were present, the maximum concentration of each to deliver a given dose would be reduced. Actual activities of radionuclides in the RWSF would be much lower than those calculated for even the 100 mrem dose.

Soils and other materials from across RFETS would be deposited in the RWSF. Average activities would be well below those calculated above for the 100 mrem annual dose, and were estimated to be below the Tier I Action Levels for radionuclides in surface soils (Am-239 = 215 pCi/g, Pu-239 = 1,429 pCi/g, and U-238 = 506 pCi/g, DOE, 1996a). The average activities for soils from the 903 Pad area, which would be deposited in the RWSF, are 10 pCi/g for Am-241, 347 pCi/g for Pu-239/240, and 3 pCi/g for U-238. This indicated that wastes that would be deposited in the RWSF would not pose a radiological health threat to operations personnel. Waste acceptance criteria (WAC) for the facility would establish conservative limits on contaminant levels in deposited wastes, and significant health and safety monitoring would also be conducted.

7.3.3 Fugitive Dust Emissions

The fugitive dust emissions study estimated maximum-allowable activities in wastes deposited in the RWSF to deliver a known dose from airborne radionuclide contaminants, transported with dust particulates, to an offsite human receptor at RFETS boundary, at 96th and Indiana Street. The study conservatively assumed a five-acre area, continuously exposed to wind erosion, with no effects from operational barriers such as cover on wastes or containers, and 1995 RFETS meteorological wind data. A fugitive dust emissions factor of 66.84 grams/m^2 per year was calculated using EPA procedures by the U. S. EPA Office of air Quality, Planning and Standards, Research Triangle Park, North Carolina. "Compilation of Air Pollutant Emission Factors", AP-42, January 1995. A regulatory limit for exposure dose was assumed to be 10 mrem per year.
By definition, the maximum limit of activity for low-level waste is 100 nCi/g, or 100,000 pCi/g, for any radionuclide or total of radionuclides. As in the worker dose calculations reported above, the upper limit activity to deliver the maximum allowable dose (10 mrem/yr) was calculated for each radionuclide. The results estimate that if 100 percent of the dust load at 96th and Indiana was from the RWSF the activities of Am-241 or Pu-239/241 could be up to 220,000 pCi/g. These calculations are included in Appendix G and include variation to the 10 mrem maximum including 9.984 mrem (10 mrem - 1996 plant contribution), 1 mrem, 5 mrem, and .5 mrem. These limits were all higher than the estimated activities for waste to be stored within the RWSF.

The actual contribution of dust from the RWSF would be much less than 100 percent and contributions from RFETS would lower the allowable activity, based on air emissions at the RWSF. However, the RWSF WAC would establish administrative controls on maximum contaminant levels at the RWSF that would be well below the level of concern for air emissions.

The average levels of radionuclides in RFETS soils were much lower than activities necessary to pose a threat to human health of a residential receptor at RFETS boundary. Average activities were not estimated for contaminated debris resulting from D&D actions. The WAC would need to ensure that levels of radionuclides in debris are controlled within acceptable limits by pre-disposal, decontamination, or packaging.

7.4 Technical and Administrative Controls

Technical and administrative controls were implemented in order to ensure that human health and the environment were protected from areas where present or past activities preclude unrestricted access or use, controls are implemented. The technical and administrative controls met the requirements in RFCA paragraph 80 for a CAMU. For the RWSF, controls could be grouped into four major elements:

- Engineering Controls (e.g. double liner system, leachate collection/detection system, cover)
- Facility Monitoring (e.g. groundwater monitoring plan)
- Operational Controls (e.g. waste acceptance criteria, inspection, H&S plan, contingency/spill response plan)
- Administrative Controls (e.g. limited access; institutional controls)

Engineering controls - There would be specific engineering controls designed into the facility in order to support protection of human health and the environment throughout the operational life of the facility. The following engineering controls of the RWSF would comply with 6 CCR 1007-3, Part 264, Subpart N, 264301 - Design and operating requirements: 264.302 - Action leakage rate; 264.303 - Monitoring and inspection; and 264.304 - Response actions:

- Double liner system (e.g. primary barrier - geosynthetic layer; secondary barrier - composite layer consisting of clay layer overlain by geosynthetic)
- Leachate collection/removal system (e.g. two systems; the first system is an integral collection/removal system constructed in the floor slab with sumps and piping; the second system is the coarse sand drainage layer above the primary barrier with integral collection pipes, pumps and sumps)
- Leak detection system (e.g. geonet layer between the primary and secondary barriers)
- Cover design which eliminates infiltration to the greatest extent practicable and promotes drainage with minimum erosion per Subpart 264.310
- An internal infrastructure designed to facilitate placement and retrieval of wastes

Facility Monitoring - In addition to the monitoring and inspection per 264.303 for the double liner system and a fully instrumented leak detection system, an extensive monitoring network would ensure no releases pass undetected from the unit boundary. This would include both air and surface water monitoring stations and groundwater monitoring wells upgradient and downgradient of the RWSF which would require a groundwater monitoring plan in accordance with 6 CRR 1007-3, Subpart S 264.552 (e) (3) and as required in Paragraph 80 of RFCA. These requirements would also be integrated into the overall RFETS Integrated Monitoring Plan program to ensure that a comprehensive network was in place to help protect human health and the environment.

Operational Controls - Operational controls would be put in place to ensure that waste management operations were conducted in such a way as to minimize the risk of release from the facility or exposure to personnel:

- An agency-approved waste acceptance criteria specifying a safety envelope for chemical and physical waste parameters including appropriate treatment requirements
- An operational health and safety plan approved by the agencies designed to provide operational constraints for personnel protection, weather conditions, decontamination procedures, training requirements, emergency response, and health and safety monitoring
- Standard operating procedures that establish clear repeatable guidelines for conduct of operations, including packaging and transporting of waste from D&D or IHSS remediation locations to the RWSF
- Numerous quality assurance procedures from construction quality assurance, as cited earlier per Subpart 264.303 (a) monitoring and inspection, to procedural audits all designed to ensure the facility and operations meet designated performance standards
- Closure plans that define how the facility would be decommissioned after the life of the operations and the performance standards for closure per Subpart 264.310 and 264.552 (e)
- Contingency/spill response plans per Subpart 264.304 would define how the facility responds to a release of waste or constituents from the RWSF

Administrative Controls - Administrative controls are defined to ensure that risk of exposure during construction, operations, and closure are minimized. These may include:

- Appropriate institutional controls (e.g. warning signs, fences, deed restrictions)
- Security plans which define site restriction requirements throughout the life of the project
- Cleanup standards which define the level of cleanup necessary to certify closure

In summary, numerous technical and administrative controls would be in place to insure that all aspects of this effort were conducted in such a way that risks to human health and the environment would be minimal.

7.5 NEPA VALUES

The proposed RWSF would be authorized using a single, integrated Decision Document that would be signed by the DOE, and the State of Colorado, when approved. The Decision Document and review process would satisfy the documentation and procedural requirements of the RFCA. The National Environmental Policy Act (NEPA) process was integrated into the RFCA documentation and procedure, especially public involvement and decision-making, to reduce duplication and paperwork, and streamline the combined NEPA/CERCLA process. In accordance with the DOE Secretarial Policy issued in June 1994, integrated CERCLA/RCRA documents for environmental clean up activities are to incorporate NEPA values to the extent practical. This policy is intended to minimize the cost and time for document preparation and review while meeting the requirements of both acts.

The RWSF would be anticipated to minimize cumulative effects on the environment by being placed in the Industrial Area because of the following:

- The proposed area in the industrial area was already contaminated and consolidation of waste is achieved
- Existing infrastructure already existed which would support the RWSF
- The proposed area was selected based on a detailed siting study which screened out sensitive areas (e.g. areas populating the endangered species Prebles Jumping Mouse, steep slopes, wetlands, etc., were avoided)

The analyses required by NEPA were integrated throughout the Decision Document, with a summary of the analyses provided in Appendix H. Based on the analyses, the decision-making process requires no further documentation to complete the NEPA process.

The alternatives analyzed, excepting the No Action alternative, would not result in irreversible damage to natural resources because releases to the environment would be averted through the use of double containment and leachate collection systems for waste storage preceding shipment. In addition, none of the alternatives analyzed will result in irreversible and irretrievable damages to natural resources because the remediation waste stored in the proposed CSF CAMU is to be shipped offsite to a disposal facility. If, at some point in the future, a proposal is advanced to use some portion of the CSF CAMU for disposal, the impact upon natural resources resulting form such a use would be analyzed at that time.

7.6 CONCEPTUAL WASTE ACCEPTANCE CRITERIA

Waste acceptance criteria (WAC) would be developed for the RWSF to ensure that remediation wastes would comply with applicable regulatory and site requirements. The WAC would set levels for those criteria that could be quantified. The WAC would undergo review and approval by regulators as part of the detailed Title II design review process. The following objectives would be achieved in compliance with the WAC:

1. Remedial wastes would be effectively isolated from potential natural environmental pathways to protect the public health and the environment.
2. RWSF operating personnel and generators would ensure continuous protection to the public health and the environment.
3. Characterization data of the remediation waste would be documented.

The RWSF would receive remediation wastes from the Site Accelerated Actions and D&D cleanup activities which include the following waste types: RCRA; TSCA; LLW; and/or LLMW. The majority of remediation waste would be handled in large bulk volumes, such as roll off containers or tandem dump trucks, rather than small containerization, such as drums or crates.

7.6.1 Physical and Chemical Compatibility Criteria

The WAC would provide physical and chemical limitations and requirements of the remediation waste and for the proper management. Process knowledge and/or chemical and radiological analyses would become the tools to document accurate characterization of the remedial waste. The following areas represent physical and chemical criteria for remedial waste compliance:

General Requirements

1. Waste in monolithic or particulate form will be accepted for disposal.
2. Waste will contain no free liquids.
3. Lack of free liquids shall be demonstrated by EPA Test Method 9095 (Paint Filter Test).
4. Gaseous waste will not be accepted. Compressed gases as defined by Title 49, CFR 173.300, including un-punctured aerosol cans, will not be accepted.
5. Aerosol cans will have punctures. Expended gas cylinders must have the valve mechanism removed and shall meet the requirements of Section 3.2.4 for debris.
6. Pyrophoric waste will not be accepted.
7. Sanitary waste will not be accepted.
8. Personnel protective equipment will be accepted.
9. Incompatible wastes will be segregated as appropriate.

Physical Requirements

1. Physical properties of monolithic bulk wastes (e.g. maximum size range, specific weight, moisture content)
2. Physical properties of wastes classified as debris (e.g. maximum size range, specific weight, biodegradable)
3. Conditions for filled and emptied containers (6 CCR 1007-3 Subpart N 264.315)
4. Prohibitions of containerized gases, free liquids, pyrophorics, and sanitary wastes
5. CCR 1007-3 Subpart N 264.312, 313, and 314)
6. Management of personal protective equipment (e.g. radiological screen of PPE after usage; followed by disposal)

Chemical Requirements

1. Chemical Analyses, acceptable analytical methods, and detection ranges.

2. Prohibited constituents and chemical characteristics including reactive or ignitable substances (e.g. pyrophoric uranium. See 6 CCR 1007-3, Subpart N, 264.312.)

3. Chemical compatibilities (6 CCR 1007-3, Subpart N, 264.313).

4. pH limitations

5. Composition of waste

7.6.2 Health and Safety - Radioactive Dose Criteria

The WAC would address the radiological limitations and requirements for the waste to meet the CAMU goals and objectives. The RWSF was categorized as less than a Category 3 Facility and designated as a Radiological Nonnuclear Facility based on a hazard categorization analysis for preliminary threshold quantity of plutonium and other radioactive isotopes (Kaiser-Hill, 1996a). All projects at RFETS are designated under two areas, safety class or non-safety class. The safety class was further defined by categories such as Category 1 and 2, with Category 1 being the higher risk. Under the non-safety class, Categories 3 and 4 exist. The RWSF was designated as less than a Category 3 Facility which, by definition, is a non-safety class in accordance with the Conduct of Engineering Manual (COEM) Volume 2, Classification of Systems, Components, and Parts; 2-D03-COEM-DES-223 Revision 1. This categorization analysis was based on sampling data from some of the more radioactive IHSSs, such as the Solar Ponds, the 903 Pad, and Lip Area, and the original Process Waste Lines. To be conservative, the highest activity concentration was used. This categorization was the lowest level of risk categorization. The facility would not receive transuranic (TRU) waste. Radiological requirements specified by the WAC would include the following:

1. Radiochemical analyses for characterization

2. Threshold limits of radionuclides for the RWSF

7.7 REMEDIATION WASTE STORAGE FACILITY OPERATIONS

The RWSF would be operated and maintained under a number of administrative requirements, as previously mentioned in section 7.4 "Technical and Administrative Controls," to ensure compliance with paragraph 80 of RFCA. Administrative controls would be administered for activities of waste operations in the following areas:

1. WAC documents and forms - These would be required to demonstrate compliance with the RWSF WAC and paragraph 80 of RFCA requirements previously mentioned in section 4.2

2. Operating procedures - Procedures for handling and placement of waste, facility maintenance and documentation to ensure safe and efficient operation of RWSF

3. Training Plans - A plan to administer required training for operating personnel in procedures, safety, and quality assurance

4. Health & Safety plans - The health and safety requirements for operating personnel to conduct operations in a safe manner

5. Contingency/spill response plans would define, per Subpart 264.03, how the facility would respond to a release of waste or constituents from the RWSF

6. Limiting operating conditions - Identification of abnormal events which would require operations to temporarily stop activities (e.g. excessive wind velocities, and other weather conditions) to ensure safety to the public, the workers, and the environment

7. Administrative procedure and plans - Additional procedures and plans to ensure compliance with RFCA, DOE orders, and RFETS rules and policies

8. Control of fugitive dust emissions - Facility Monitoring plan as cited in section 7.4 to reduce dust emissions and monitor results to protect the public and worker

9. Closure Plan - This would include the requirements and performance standards for closure per Subpart 264.310 and 264.552 (e) to close the facility after the end of its operational life

Additional requirements addressed in the WAC or Facility Operations Plan for compliance were areas addressing administrative controls. The following requirements would ensure the RWSF to be operated in a safe manner:

- Recordkeeping and documentation
- Waste information from process knowledge and/or sampling and analysis data for waste characterization
- Quality assurance/quality control (QA/QC) certification program and verification;
- Status reports and waste forecasts
- Shipment notification
- Packaging and labeling requirements

10. Inspection Plan - Perimeter monitoring of the waste facility will occur on an interval basis as defined in the inspection plan to be submitted as part of the design. Inspection points within the facility will be identified and may include surface leak collection channels, internal module boundaries, outside wall joints, and leachate sumps.

7.8 CONCLUSION

The RWSF is proposed as a contingency to the existing Ten Year Plan, which now calls foe all low-level and low-level mixed wastes to be disposed offsite as it is generated. This IM/IRA Decision Document is the tool to designate the proposed Solar Ponds area as a CAMU for storage of remediation waste as a contingency to the Ten Year Plan. The RWSF must meet the applicable requirements in 6 CCR 1007-3, Part 264, Subpart N. The Decision Document identifies and explains, in a detailed study and analysis, the best location onsite for the selected remedy—the Concrete-lined Cell. In the event remediation waste could not be shipped offsite when generated as anticipated under the Ten Year Plan, then the DOE could implement the CAMU as their contingency for storage of remediation waste. The operational life for the CAMU is proposed to be approximately 25 years.

8.0 SCHEDULE

This Section provides a conceptual schedule for the CAMU process. It includes the designation process outlined in the RFCA, then presents the duration for design and construction of the RWSF if it is constructed. Except for the designation of CAMU, all other activities would be contingency actions to the TYP should the need arise for onsite bulk storage.

This Gantt chart presents project task information as both text and graphics. Information about each task is listed in the Gantt table on the left side of the figure. The Gantt bar chart displays task durations and start and finish dates on a time scale. The relative positions of the task bars show which tasks start and finish before each other and which task overlap other tasks.

In paragraph 109 of RFCA, subparagraphs (b) and (c) durations for the CAMU designation process are given as such:

b. Within 45 days of receipt of DOE's draft IM/IRA, CDPHE shall determine whether the IM/IRA meets or fails to meet the criteria in subparagraph (a). If CDPHE determines that the draft fails to meet the criteria, the draft shall, at the end of a 45-day review, explain with specificity the necessary modifications and allow the DOE to resubmit within 30 days, or to invoke dispute resolution within 14 days. If the CDPHE determines that the application meets the criteria described in subparagraph (a), the CDPHE shall issue the draft IM/IRA for public comment for a period of 60 days.

c. Within 30 days of the close to the public comment period, the CDPHE shall review the comments received and modify the draft, if appropriate. The agency shall also prepare a response to significant public comments at this time. At the end of this 30-day period, if the CDPHE still agrees that the IM/IRA, as modified, meets the regulatory criteria for designation and the criteria in paragraph 80, the CDPHE shall designate the storage CAMU. If the CDPHE has determined that the IM/IRA does not meet these same criteria, the CDPHE shall state the changes that DOE must make to receive approval.

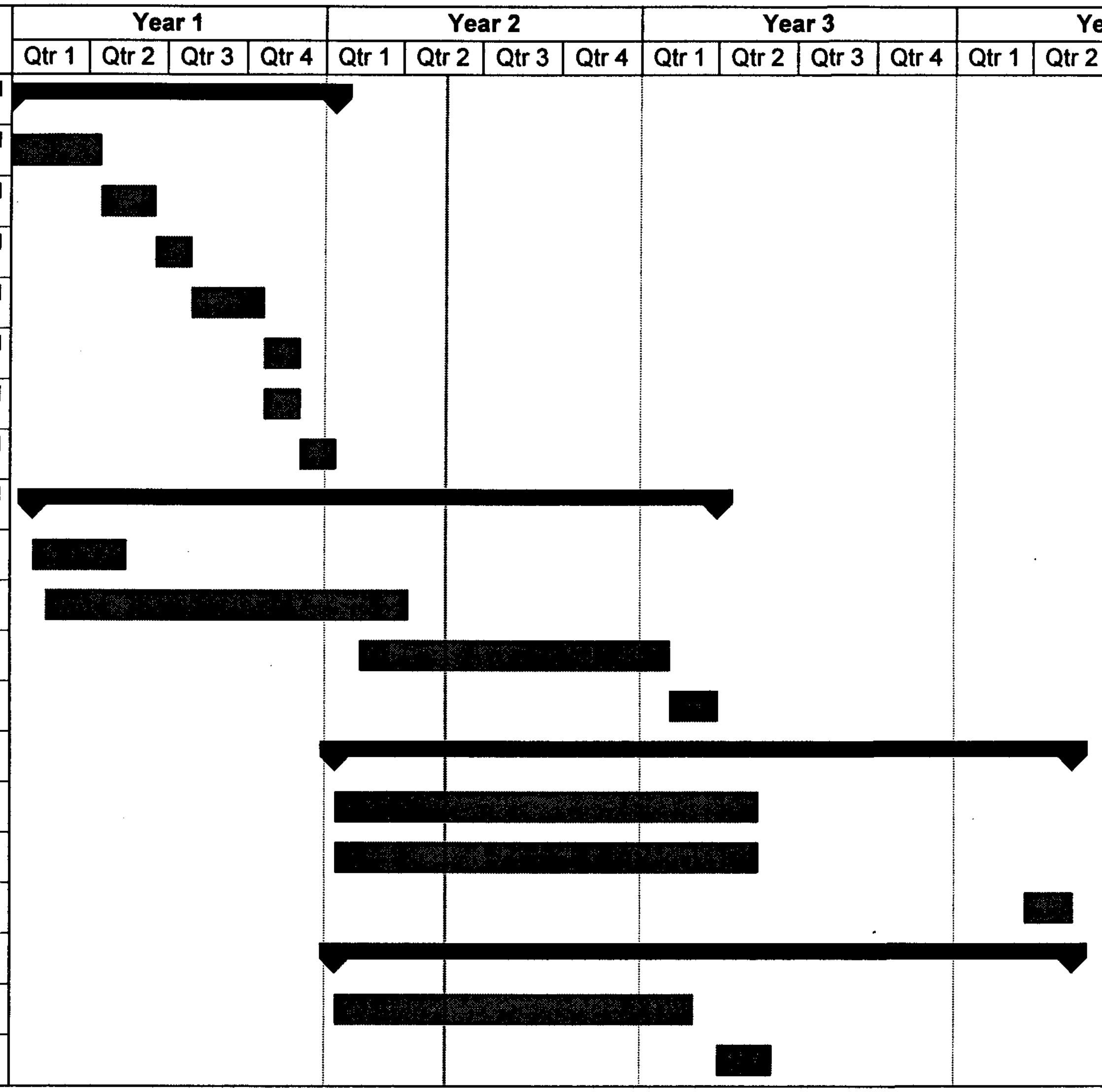
Once the CAMU designation is complete, design and construction of the RWSF would be dependent on the need to implement this CAMU contingency to support risk reduction. Construction of the facility, including design, is estimated to take a little more than two years. Placement of remediation waste in the facility would be dependent on the progress of D&D and remediation activities.

The Ten Year Plan assumes that all low-level mixed waste would be disposed offsite. The actual shipping schedule would be dependent on funding and the availability of offsite facilities. Since this is a contingency, no schedule for eventual shipment of the waste in the RWSF offsite has yet been determined

The schedule for implementation of this Decision Document is provided as a Gantt Chart in Figure 8-1.

FIGURE 8-1: PROPOSED REMEDIATION WASTE STORAGE FACILITY SCHEDULE

ID	Task Name	Duration
1	**Decision Document**	271d
2	PREPARE DECISION DOCUMENT (DD)	76d
3	CDPHE REVIEW DD	45d
4	MODIFY DD BASED ON CDPHE COMMENTS	30d
5	PUBLIC COMMENT PERIOD ON THE DD	60d
6	MODIFY DD BASED ON PUBLIC COMMENT	30d
7	PREPARE RESPONSIVENESS SUMMARY	30d
8	FINAL APPROVAL OF DD	30d
9	**Design**	568d
10	GEOTECHNICAL INVESTIGATION	78d
11	PREPARE CONCEPTUAL DESIGN	300d
12	PREPARE DETAILED DESIGN	257d
13	PUBLIC COMMENT AND REVIEW	40d
14	**Operational and Monitoring Plan Preparation**	612d
15	PREPARE OPERATIONAL DOCUMENTATION	350d
16	PREPARE MONITORING PLAN	350d
17	OPERATIONAL TESTING	40d
18	**Construction**	612d
19	PRECONSTRUCTION PLAN PREPERATION	297d
20	PREPARE SITE FOR CONSTRUCTION	45d



PROPOSED REMEDIATION WASTE STORAGE FACILITY SCHEDULE

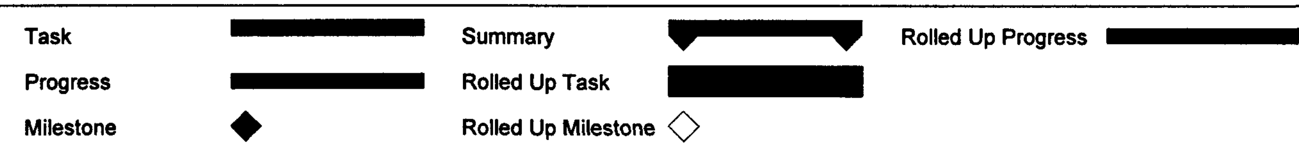
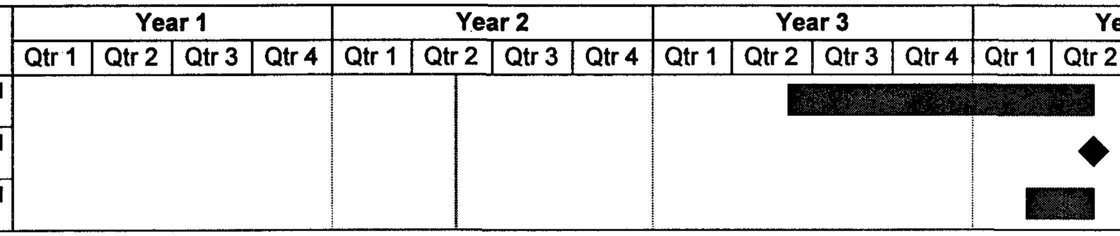


FIGURE 8-1: PROPOSED REMEDIATION WASTE STORAGE FACILITY SCHEDULE

ID	Task Name	Duration
21	CONSTRUCTION OF PREFERED ALTERNATIVE	250d
22	**Begin Operations**	0d
23	**Project Close-Out**	55d



PROPOSED REMEDIATION WASTE STORAGE FACILITY SCHEDULE

Task	Summary
Progress	Rolled Up Task
Milestone	Rolled Up Milestone
Rolled Up Progress	

9.0 REFERENCES

DOE, 1995a, EG&G Rocky Flats Environmental Technology Site Land Use Manual, Manual No. 3-END.01.

DOE, 1995b, Programmatic Rick-Based Preliminary Remediation Goals, Rev. #2.

DOE, 1996a, Final Rocky Flats Cleanup Agreement, July 16.

DOE, 1996b, Draft Ten Year Plan, July 30.

EPA, 1985 "Covers for uncontrolled Hazardous Waste Sites" (EPA/540/2-85/002).

EG&G, 1994, INEL, Interim Report; Waste Management Facilities Costs, Information for Mixed Low-Level Waste; March 1994.

Kaiser-Hill, 1996b, Vision of the Rocky Flats Environmental Technology Site, February 9.

Kaiser-Hill, 1996a, Hazard Categorization Analysis for Waste Management Facility, January.

Looby, T., CDPHE, 1995, to J. McGraw, EPA, and M. Silverman, DOE, Subject: Principles for On-Site Disposal of Contaminated Materials, February 27.

RMRS, 1996, White Paper; Analyses of Potential Vertical Contaminant Migration Potential, (RF/ER-96-0040.UN), August 16, 1996. Report prepared for the Kaiser-Hill Company.

guidelines will be contained in the IGD, in Appendix 3. While these guidelines are not binding on DOE, CDPHE and EPA will use them in reviewing the adequacy of documents submitted and work proposed by DOE.

79. To expedite remedial work and maximize early risk reduction at the Site, the Parties intend to make extensive use of accelerated actions to remove, stabilize, and/or contain Individual Hazardous Substance Sites (IHSSs). Focussing on IHSSs rather than OUs will allow most remedial work to be reviewed and conducted through one of the accelerated review and approval processes described in Part 9, rather than the RI/FS process. The Parties have agreed upon a risk ranking of the IHSSs, which is contained in Attachment 4. The ranking of IHSSs will be reviewed annually, and may be revised as appropriate. The Parties will consider the risk ranking and other factors to prioritize work for the baseline, in accordance with Part 11 (Budget and Work Planning).

80. The Parties recognize that the facility described in this paragraph providing for retrievable, monitored storage of remediation wastes may be converted at a future date to a disposal facility. The Parties also recognize that some remedial actions (e.g., in-place closures) may incorporate disposal as an initial proposal. The Parties anticipate that consistent with the Preamble Objectives, retrievable, monitored storage of remediation wastes (except for TRU or TRU mixed wastes), with an option for conversion to disposal in-place in accordance with future decision-making, may be accomplished through use of a Corrective Action Management Unit (CAMU). The Parties agree that the design criteria for the facility described in this paragraph shall be the same whether the facility is for the retrievable, monitored storage of remediation wastes or for the disposal of remediation wastes. Specifically, the facility described in this paragraph must ensure retrievability of wastes and protection of human health and the environment through a combination of requirements that include, but are not limited to: detection and monitoring/inspection requirements; operating and design requirements, including cap/liner system that meets the requirements as set forth in 6 CCR § 1007-3, Part 264, Subpart N; a ground water monitoring system; and requirements for responding to releases of wastes or constituents from the units. In addition, where necessary for protection of human health and environment, waste treatment will be required. If DOE proposes a CAMU, it is the expectation of the Parties that if the application meets the appropriate substantive criteria, CDPHE will issue a CAMU designation for storage or disposal in a timely fashion, consistent with its general commitment to expedite regulatory approval of those activities required to achieve the Preamble Objectives. If DOE proposes a storage CAMU, it may request that CDPHE make findings of fact as to whether the proposed facility also meets the requirements for a disposal CAMU that are in effect at the time of the request. CDPHE agrees to make such findings upon request. The Parties also agree that a CAMU for remediation wastes and another RCRA/CHWA Subtitle C unit for storage or disposal of process wastes (except TRU and TRU mixed wastes) not regulated under this Agreement may be co-located. The review, approval and oversight of any unit for process wastes is also not regulated under this Agreement, but by CDPHE under the existing CHWA permit, as set forth in Appendix 8.

81. For purposes of this Agreement, wastes generated by activities regulated under this Agreement are remediation wastes. All such wastes, except for TRU and TRU mixed wastes, are suitable for storage or disposal in an approved on-site CAMU, in accordance with the terms of any such approval.

82. Any proposal for a centralized facility at RFETS for the retrievable, monitored storage or disposal of remediation wastes shall be subject to approval only by CDPHE as the LRA, regardless of its location. Notwithstanding any other provision of this Agreement regarding the role of the SRA, EPA may participate fully in the review and consultative processes related to such a facility. In addition, EPA shall have the right to invoke the dispute resolution provisions of Part 15E regarding any CDPHE decision related to such a facility, within 15 days of the issuance of any such decision.

83. Following implementation of all planned accelerated actions, CDPHE and EPA shall evaluate the Site conditions and render final remedial/corrective action decisions for each OU. Notwithstanding the emphasis on accelerated actions and IHSS-based approach, the Parties recognize that the final remedial/corrective action decisions may require some additional work as specified in the CAD/ROD to ensure an adequate remedy.

84. Following implementation of all planned accelerated actions, for the Industrial Area OU, CDPHE will make a final corrective action decision for hazardous constituents pursuant to its CHWA regulatory authority, and DOE, consistent with its authority under CERCLA § 120, shall make a proposed remedial decision under CERCLA. CDPHE shall make a recommendation to EPA whether to concur with DOE's proposed remedial decision for radionuclides and other hazardous substances that are not hazardous constituents. EPA, consistent with CERCLA § 120, shall review DOE's proposed remedial decision and CDPHE's recommendation thereon, and shall then concur or non-concur with DOE's proposed remedy. EPA's decision regarding radionuclides and other hazardous substances that are not hazardous constituents shall incorporate CDPHE's recommendation, so long as EPA determines that the recommendation is consistent with CERCLA. EPA and DOE, consistent with CERCLA § 120, shall also review CDPHE's corrective action decision and shall issue a concurrence remedial action decision under CERCLA, so long as CDPHE's selected corrective action decision is consistent with CERCLA.

85. Following implementation of all planned accelerated actions, for those OUs in the Buffer Zone or offsite, EPA and DOE, consistent with CERCLA § 120, will make a final remedial decision pursuant to CERCLA. CDPHE shall review the final remedial decision and shall issue a concurrence corrective action decision under CHWA, so long as the final remedial action is consistent with CHWA and applicable State law.

PART 9 REVIEW AND APPROVAL OF DOCUMENTS AND WORK

Subpart A. General

86. The provisions of this Part establish the procedures that shall be used by the Parties to provide each other with appropriate notice, review, comment, and responses to comments regarding submitted documents. As of the effective date of this Agreement, all documents identified herein shall be prepared, distributed, reviewed, approved or disapproved, and subject to dispute resolution in accordance with this Part. The Parties shall implement the provisions of this Part in consultation with each other. Schedules for submittal of documents are contained in the baseline in Appendix 4. Procedures in this Part for the review and approval of CAD/RODs shall not alter, but shall supplement the procedures set forth in paragraphs 83 and 84.

scoping process described in paragraph 89, unless the LRA extends this period based on good cause communicated to DOE in a timely fashion. If the LRA disapproves the revised IM/IRA, it shall state the changes that DOE would have to make to receive approval. DOE shall then have 21 days to incorporate the LRA's changes or invoke dispute resolution. If the LRA does not approve or disapprove the revised IM/IRA within the time allotted (including any extension of time), any milestone associated with the IM/IRA shall be suspended and will be re-established as agreed by the Parties. If the Parties cannot agree, EPA and CDPHE shall unilaterally re-establish the milestone. A unilaterally re-established milestone shall be extended by a period no less than the excess time taken by the LRA to render the IM/IRA decision.

108. If there is an activity that DOE expects to undertake in the Industrial Area which is an activity listed as requiring a Class 3 permit modification pursuant to CHWA regulations, and for which no permit by rule would be available, DOE shall--prior to submitting the draft IM/IRA to CDPHE, but after the scoping period--make the draft IM/IRA available for a 60 day public comment period. DOE shall transmit all comments to CDPHE for its subsequent review. CDPHE shall use its best efforts to issue its draft decision, including applicable requirements, and other information as required by current regulation within 30 days of receipt of the draft IM/IRA and public comments. This draft decision shall itself be made available for public comment for 60 days, with an opportunity for public hearing. Within 30 days of the close of the public comment period, CDPHE shall revise its proposed decision accordingly and respond to significant public comment. If CDPHE denies DOE the authority to proceed with the activity or imposes conditions thereon with which DOE disagrees, DOE may invoke dispute resolution.

109. Since the beginning of FY 1996, DOE has engaged members of the public in an on-going conversation, including a dozen meetings and work sessions, regarding whether and how to construct a storage or disposal facility for remediation wastes at RFETS. As a result of this interaction, DOE's ideas about the design and purposes of such a facility have evolved. DOE anticipates that it will be applying during 1996 for designation of a storage CAMU. The Parties commit to a meeting with the public to discuss the CAMU application prior to its submission.

a. When DOE determines that it is prepared to seek designation of a CAMU for storage of remediation wastes, DOE shall submit a draft IM/IRA to EPA and CDPHE which satisfies applicable regulatory criteria for designation and the criteria described in paragraph 80, and presents an analysis of alternatives showing that DOE has considered the following:

(1) worker safety,
(2) protection of public health and the environment,
(3) transportation,
(4) facility design, containment and monitoring,
(5) institutional controls,
(6) cost, and
(7) community acceptance.

The Parties recognize the special expertise of CDPHE with respect to the design of hazardous waste storage and disposal facilities. Therefore, with respect to DOE's obligation to incorporate NEPA values into any decision document associated with the designation of a CAMU at RFETS, CDPHE will be designated by DOE as a cooperating agency to assist DOE in the analysis of reasonable alternatives, including the "No Action" alternative. As a cooperating agency, CDPHE's participation will be sought by DOE early in the alternatives analysis process to ensure CDPHE's special expertise is available to DOE as it incorporates relevant NEPA values into any decision document associated with the designation of a CAMU.

b. Within 45 days of receipt of DOE's draft IM/IRA, CDPHE shall determine that the IM/IRA meets or fails to meet the criteria in subparagraph (a). If CDPHE determines that the draft fails to meet the criteria, it shall, at the end of its 45 day review, explain with specificity the necessary modifications and allow DOE to resubmit within 30 days or to invoke dispute resolution within 14 days.If CDPHE determines that the application meets the criteria described in subparagraph (a), it shall issue the draft IM/IRA for public comment for a period of 60 days.

c. Within 30 days of the close of the public comment period, CDPHE shall review the comments received and modify the draft if appropriate. The agency shall also prepare a response to significant public comments during this time. At the end of this 30 day period, if CDPHE still agrees that the IM/IRA as modified meets the regulatory criteria for designation and the criteria in paragraph 80, CDPHE shall designate the storage CAMU. If CDPHE has determined that the IM/IRA does not meet these same criteria, it shall state the changes that DOE must make to receive approval.

d. Time is of the essence regarding a final decision on a storage CAMU for remediation wastes. CDPHE recognizes this, and has therefore committed to the review times set forth in this paragraph. CDPHE's failure to meet these time frames does not result in approval of the proposed document.

110. If DOE determines, after a process of public consultation that shall occur in accord with the Community Relations Plan, and after consideration of:

a. protection of public health and the environment;
b. worker safety;
c. transportation;
d. facility design, containment and monitoring;
e. institutional controls;
f. cost; and
g. community acceptance

that it intends to proceed with either (i) building a new on-site disposal facility for remediation waste, or (ii) converting or upgrading an existing unit at Rocky Flats into a disposal facility for remediation wastes, DOE shall apply to CDPHE in accord with then-applicable law. The application shall describe the types of wastes that would be disposed, the location of the facility and its design, along with other information as specified in the IGD; include an analysis of alternatives; and demonstrate that the facility would meet then-applicable legal requirements. This application shall be processed either as an accelerated action pursuant to the process established in RFCA paragraphs 89, 107 and 108, or as part of the CAD/ROD, whichever is appropriate at the time, as well as in a manner that is consistent with then-applicable requirements.

111. DOE shall submit appropriate Air Pollution Emission Notices as part of the draft decision document for all work, regardless of whether it is to be performed in the Industrial Area or the Buffer Zone. This information shall be available for inspection at RFETS.

112. In responding to draft decision documents that are not Site-Wide documents, the LRA shall obtain comments from and, where appropriate, consult with the SRA. Following such consultation with the SRA (if any) the LRA shall submit a single set of consistent, consolidated comments to DOE on or before the close of the comment period. The LRA agrees to use its best efforts to provide a comprehensive set of comments on draft documents to DOE so as to avoid, to the extent possible, raising issues of first impression at a later stage. Comments shall be provided with adequate specificity so that DOE may respond to the comments and, if appropriate, make changes to draft documents. If the LRA takes more time than allotted pursuant to paragraph 89 to respond to a draft decision document, such a delay may constitute good cause for regulatory milestone modifications.

113. For Site-Wide documents, EPA and CDPHE shall attempt to reach concurrence and provide DOE with a single set of consistent, consolidated comments to DOE on or before the close of the comment period. EPA and CDPHE agree to use their best efforts to provide a comprehensive set of comments on draft documents to DOE so as to avoid, to the extent possible, raising issues of first impression at a later stage. Comments shall be provided with adequate specificity so that DOE may respond to the comments and, if appropriate, make changes to draft documents. If the regulators take more time than allotted pursuant to paragraph 89 to respond to a draft decision document, such delay may constitute good cause for regulatory milestone modifications.

114. Following the close of the review and comment period for a draft decision document (including any public comment), DOE shall prepare a proposed final decision document. In so doing, it shall give full consideration to all written comments submitted by the LRA (or, in the case of Site-Wide documents, EPA and CDPHE). DOE shall seek clarification of the intent and purpose of any comment from the LRA (or, in the case of Site-Wide documents, EPA and CDPHE) that DOE finds is unclear before preparing the proposed final decision document.

115. The LRA (or, in the case of Site-Wide documents, EPA and CDPHE) shall review the proposed final decision document and shall approve or disapprove it. If the proposed final decision document is approved, that document shall become final. If the LRA disapproves a document, it must explain the necessary modifications or reasons for disapproval and delineate the actions that must be taken for approval. If the proposed final decision document is disapproved, DOE shall revise and re-submit those portions of the document that require revision in compliance with the notice of disapproval, unless DOE invokes dispute resolution pursuant to Subpart 15B or 15E, as appropriate, within the period allowed for re-submittal. When dispute resolution is invoked on a proposed final document, work may be stopped in accordance with the procedures set forth in Part 14.

Subpart S-Corrective Action

§ 264.552 Corrective Action Management Units (CAMU).

(a) For the purpose of implementing remedies under § 264.101, § 265.5 or section 25-15-308, C.R.S., the Department may designate an area at the facility as a corrective action management unit, as defined in § 260.10, in accordance with the requirements of this section. One or more CAMUs may be designated at a facility.

(1) For the purposes of the application of the land disposal restrictions found in Part 268, placement of remediation wastes into or within a CAMU does not constitute land disposal of hazardous wastes.

(2) For the purposes of the application of the minimum technology requirements of 40 CFR § 268.5(h)(2), or of the minimum technology requirements of Subparts K, L, M, or N, or the groundwater protection requirements of Subpart F or the closure and post-closure requirements of Subpart G of Part 264 or 265 of these regulations, consolidation or placement of remediation wastes into or within a CAMU does not constitute creation of a regulated unit.

(3) Where the remediation wastes placed into a CAMU are hazardous waste, the CAMU shall comply with Subparts B, C, D and E of Part 264 or 265 of these regulations and, when such remediation wastes will remain in place after closure of the CAMU, the CAMU shall comply with the regulations for the siting of hazardous waste disposal sites, 6 CCR 1007-2, Part 2.

(b)(1) The Department may designate a regulated unit (as defined in § 264.90(a)(2)) as a CAMU, or may incorporate a regulated unit into a CAMU, if:

(i) The regulated unit is closed or closing, meaning it has begun the closure process under § 264.113 or § 265.113; and

(ii) Inclusion of the regulated unit will enhance implementation of effective, protective and reliable remedial actions for the facility.

(2) The subpart F and G requirements and the unit-specific requirements of part 264 or 265 and the financial assurance requirements of Part 266 that applied to that regulated unit will continue to apply to that portion of the CAMU after incorporation into the CAMU.

(c) The Department shall designate a CAMU in accordance with the following:

(1) The CAMU shall facilitate the implementation of reliable, effective, protective, and cost-effective remedies;

(2) Waste management activities associated with the CAMU shall not create unacceptable risks to humans or to the environment resulting from exposure to hazardous wastes or hazardous constituents;

(3) The CAMU shall include uncontaminated areas of the facility, only if including such areas for the purpose of managing remediation waste is more protective than management of such wastes at contaminated areas of the facility;

(4) Areas within the CAMU, where remediation wastes remain in place after closure of the CAMU, shall be managed and contained so as to control, minimize, or eliminate future releases to the extent necessary to protect human health and the environment;

(5) The CAMU shall expedite the timing of remedial activity implementation, unless to do so would be inconsistent with § 264.552(c)(1) or (c)(2).

(6) The CAMU shall enable the use, when appropriate, of treatment technologies (including innovative technologies) to enhance the long-term effectiveness of remedial actions by reducing the toxicity, mobility, or volume of remediation wastes that will remain in place after closure of the CAMU; and

(7) The CAMU shall minimize the land area of the facility upon which remediation wastes will remain in place after closure of the CAMU, unless to do so would be inconsistent with § 264.552(c)(1) or (c)(2).

(d) The owner/operator shall provide sufficient information to enable the Department to designate a CAMU in accordance with the criteria in § 264.552.

(e) The Department shall specify, in the permit or order, requirements for CAMUs to include the following:

(1) The areal configuration of the CAMU.

(2) Requirements for remediation waste management to include the specification of applicable design, operation and closure requirements.

(3) Requirements for ground water monitoring that are sufficient to:

(i) Continue to detect and to characterize the nature, extent, concentration, direction, and movement of existing releases of hazardous constituents in ground water from sources located within the CAMU; and

(ii) Detect and subsequently characterize releases of hazardous constituents to ground water that may occur from areas of the CAMU in which remediation wastes will remain in place after closure of the CAMU.

(4) Closure and post-closure requirements.

(i) Closure of corrective action management units shall:

(A) Minimize the need for further maintenance; and

(B) Control, minimize, or eliminate, to the extent necessary to protect human health and the environment, for areas where remediation wastes remain in place, post-closure escape of hazardous waste, hazardous constituents, leachate, contaminated runoff, or hazardous waste decomposition products to the ground, to ground water, to surface waters, or to the atmosphere.

(ii) Requirements for closure of any CAMU shall include the following, as appropriate and as deemed necessary by the Department to protect human health and the environment:

(A) Requirements for excavation, removal, treatment or containment of remediation wastes;

(B) For areas in which remediation wastes will remain after closure of the CAMU, requirements for lining and/or capping of such areas; and

(b) Any temporary unit to which alternative requirements are applied in accordance with paragraph (a) of this section shall be:

(1) Located within the facility boundary; and

(2) Used only for treatment or storage of remediation wastes.

(c) In establishing standards to be applied to a temporary unit, the Department shall consider the following factors:

(1) Length of time such unit will be in operation;

(2) Type of unit;

(3) Volumes of remediation wastes to be managed;

(4) Physical and chemical characteristics of the remediation wastes to be managed in the unit;

(5) Potential for releases from the unit;

(6) Hydrogeological and other relevant environmental conditions at the facility which may influence the migration of any potential releases; and

(7) Potential for exposure of humans and environmental receptors if releases were to occur from the unit.

(d) The Department shall specify in the permit or order the length of time a temporary unit will be allowed to operate, to be no longer than a period of one year. The Department shall also specify the design, operating, and closure requirements for the unit.

(e) The Department may extend the operational period of a temporary unit once for no longer than a period of one year beyond that originally specified in the permit or order, if the Department determines that:

(1) Continued operation of the unit will not pose a threat to human health and the environment; and

(2) Continued operation of the unit is necessary to ensure timely and efficient implementation of remedial actions at the facility.

(f) Incorporation of a temporary unit or a time extension for a temporary unit into an existing permit shall be:

(1) Approved in accordance with the procedures for Department-initiated permit modifications under § 100.61; or

(2) Requested by the owner/operator as a Class II modification according to the procedures under § 100.63 of these regulations.

(g) Incorporation of a temporary unit or a time extension for a temporary unit into a new permit shall be approved by the Department according to the permit review and issuance procedures of § 100.5 of these regulations.

(h) Incorporation of a temporary unit or a time extension for a temporary unit into an order issued pursuant to § 265.5 must be in accordance with the permits by rule provisions of § 100.21(e) of these regulations.

(i) The Department shall document the rationale for designating a temporary unit and for granting time extensions for temporary units and shall make such documentation available to the public.

Subparts T through V [Reserved]

Appendix B

Appendix B-1: Facility Drawings

Appendix B-2 : Preliminary Design Narrative

Appendix B-3: Designation Support Documentation

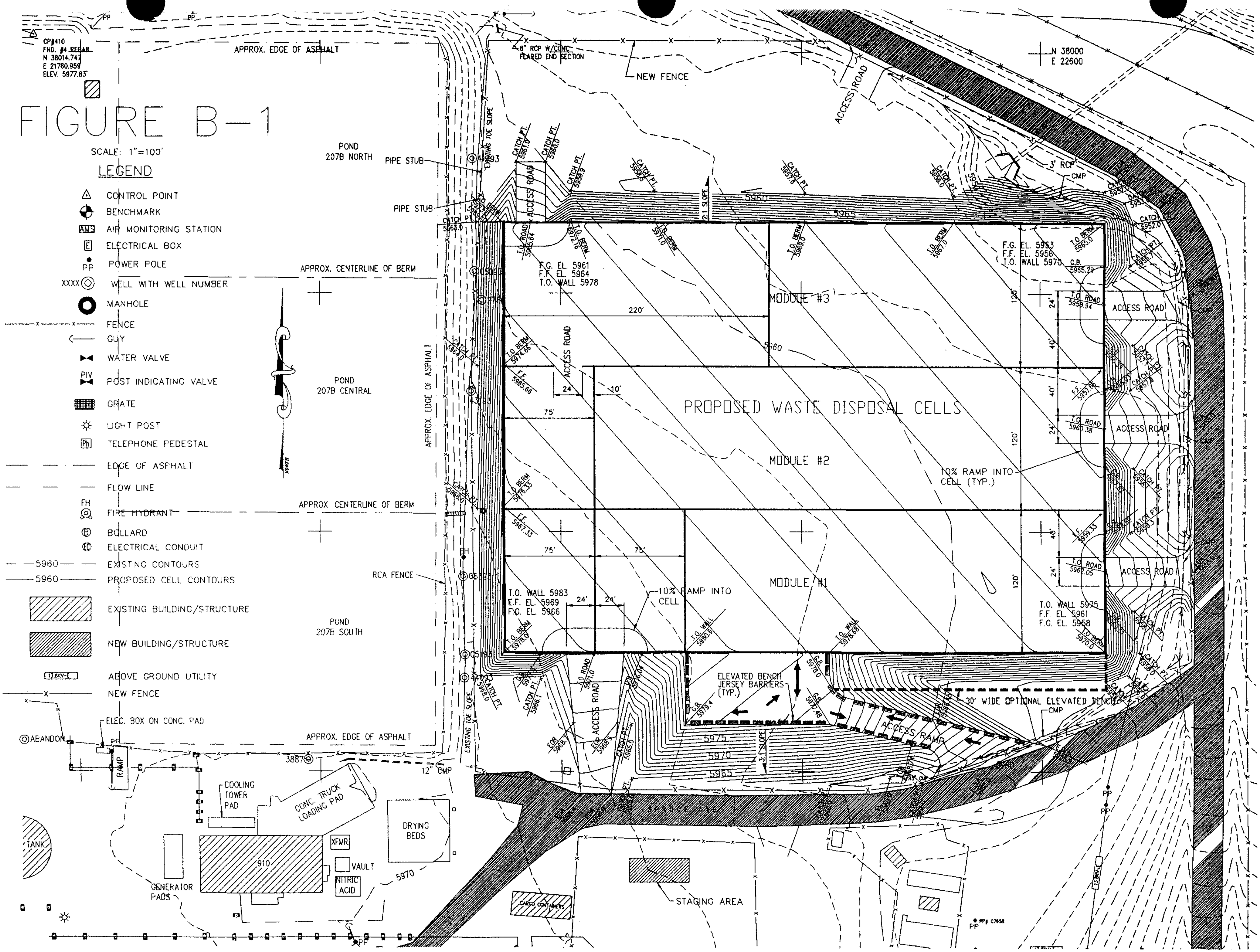
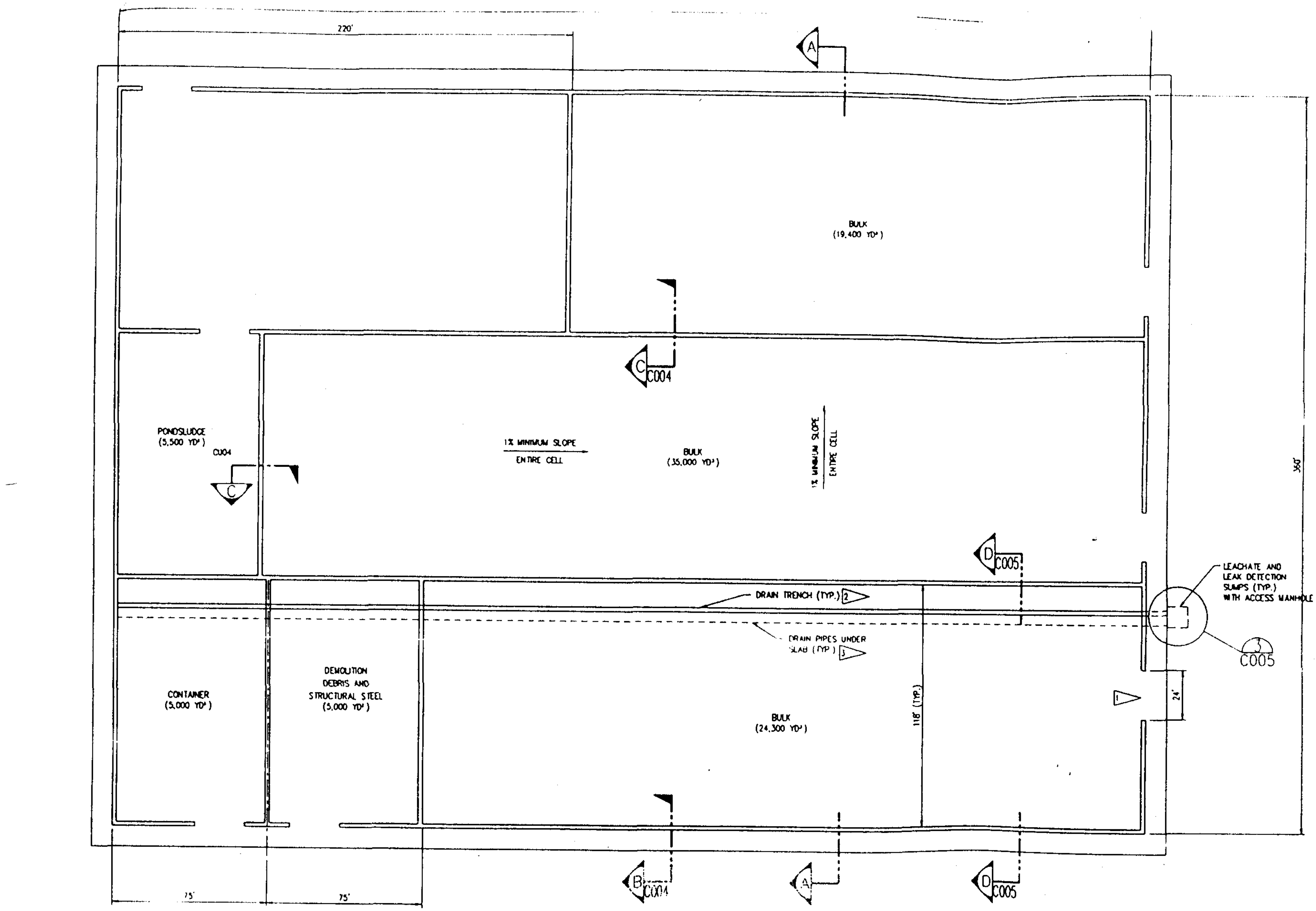
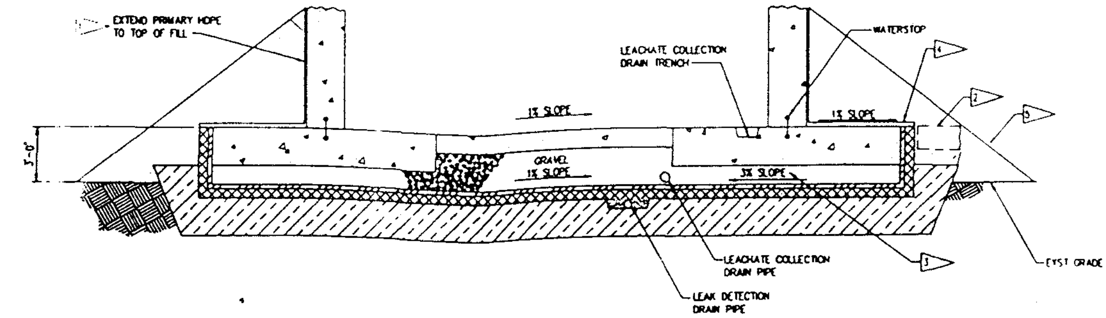


FIGURE B-1
SCALE: 1"=100'
LEGEND
CONTROL POINT
BENCHMARK
AIR MONITORING STATION
ELECTRICAL BOX
POWER POLE
WELL WITH WELL NUMBER
MANHOLE
FENCE
GUY
WATER VALVE
POST INDICATING VALVE
GRATE
LIGHT POST
TELEPHONE PEDESTAL
EDGE OF ASPHALT
FLOW LINE
FIRE HYDRANT
BOLLARD
ELECTRICAL CONDUIT
5960 EXISTING CONTOURS
5960 PROPOSED CELL CONTOURS
EXISTING BUILDING/STRUCTURE
NEW BUILDING/STRUCTURE
ABOVE GROUND UTILITY
NEW FENCE
ELEC. BOX ON CONC. PAD
CP#410
FND. #4 REBAR
N 38014.747
E 21760.959
ELEV. 5977.83'
N 38000
E 22600
PROPOSED WASTE DISPOSAL CELLS
MODULE #1
MODULE #2
MODULE #3
POND 207B NORTH
POND 207B CENTRAL
POND 207B SOUTH
APPROX. EDGE OF ASPHALT
APPROX. CENTERLINE OF BERM
PIPE STUB
RCA FENCE
NEW FENCE
ACCESS ROAD
ACCESS RAMP
10% RAMP INTO CELL (TYP.)
10% RAMP INTO CELL
ELEVATED BENCH JERSEY BARRIERS (TYP.)
30' WIDE OPTIONAL ELEVATED BENCH
F.G. EL. 5961
F.F. EL. 5964
T.O. WALL 5978
F.G. EL. 5953
F.F. EL. 5956
T.O. WALL 5970
T.O. WALL 5983
F.F. EL. 5969
F.G. EL. 5966
T.O. WALL 5975
F.F. EL. 5961
F.G. EL. 5968
8" RCP W/CONC. FLARED END SECTION
3' RCP
12" CMP
EXISTING TOE SLOPE
2:1 SLOPE
3:1 SLOPE
SPRUCE AVE.
STAGING AREA
CARGO CONTAINERS
DRYING BEDS
CONC. TRUCK LOADING PAD
COOLING TOWER PAD
910
XFMR
VAULT
NITRIC ACID
GENERATOR PADS
TANK
RAMP
ABANDON

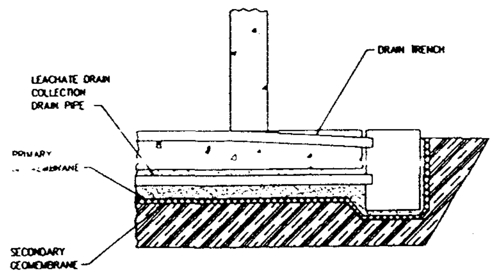


Cell Layout (Example of Waste Segregation)

Figure B-2



D CELL LINER
C003 NOT TO SCALE



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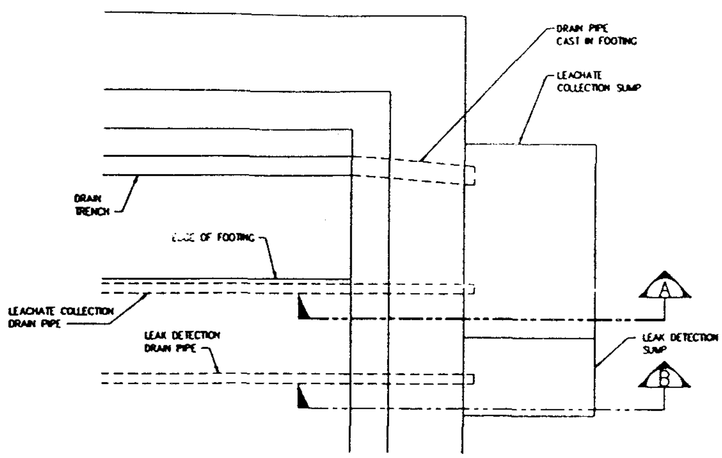

3 LEACHATE COLLECTION & LEAK DETECTION – PLAN VIEW
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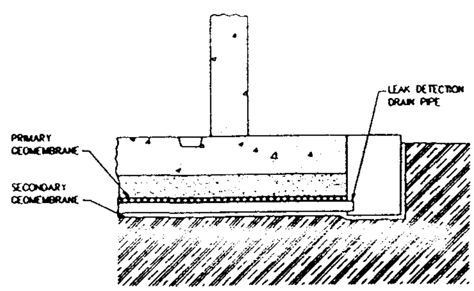
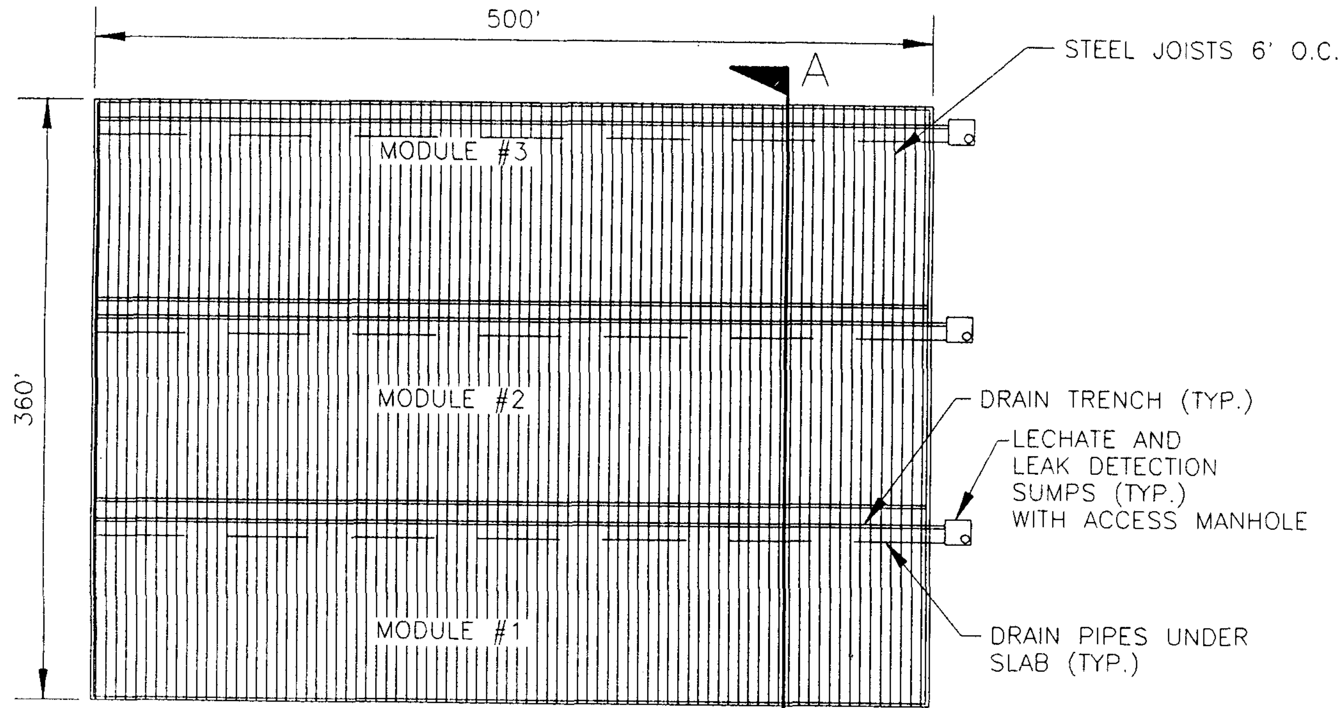
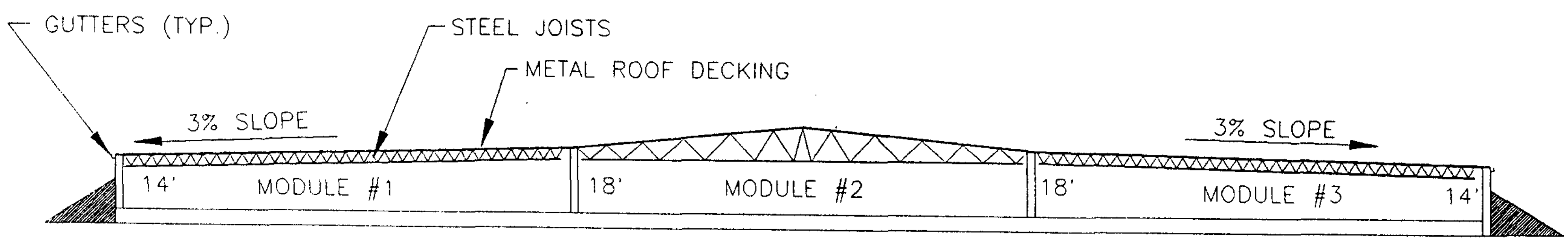


B LEAK DETECTION SUMP
NOT TO SCALE

Figure B-3



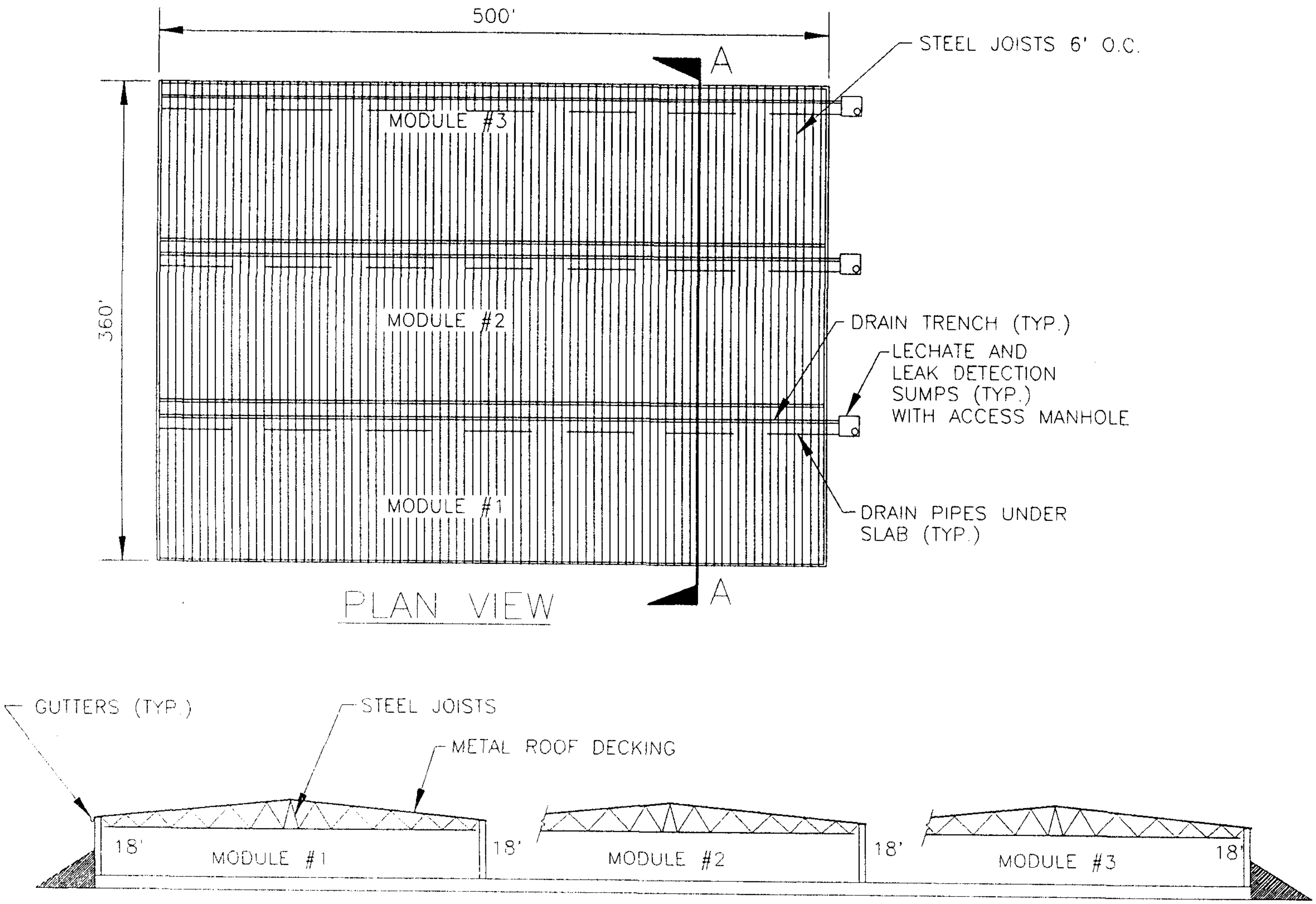
PLAN VIEW



BUILDING SECTION A–A

METAL ROOF DECK

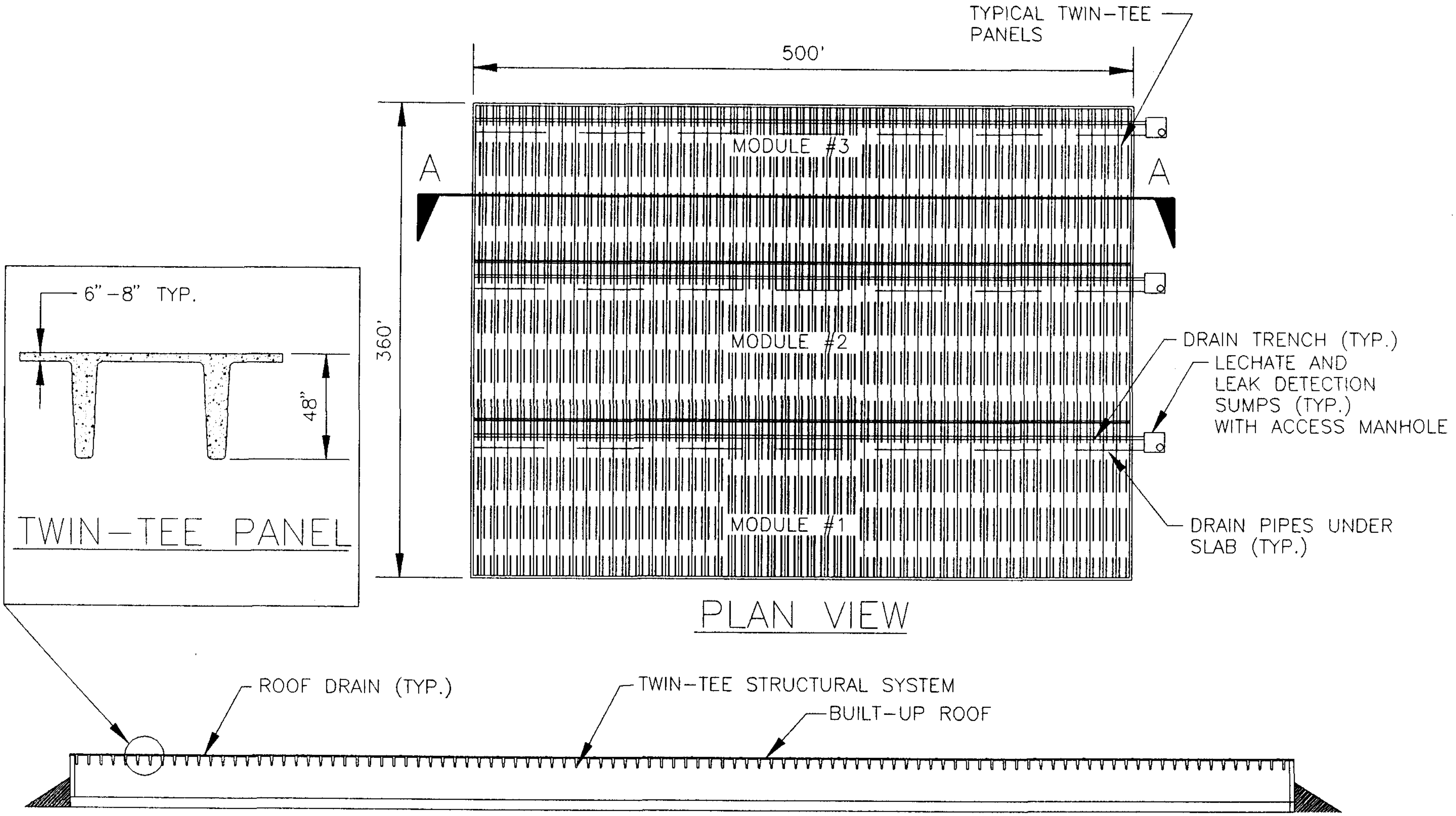
FIGURE B-4A



BUILDING SECTION A–A

METAL ROOF DECK

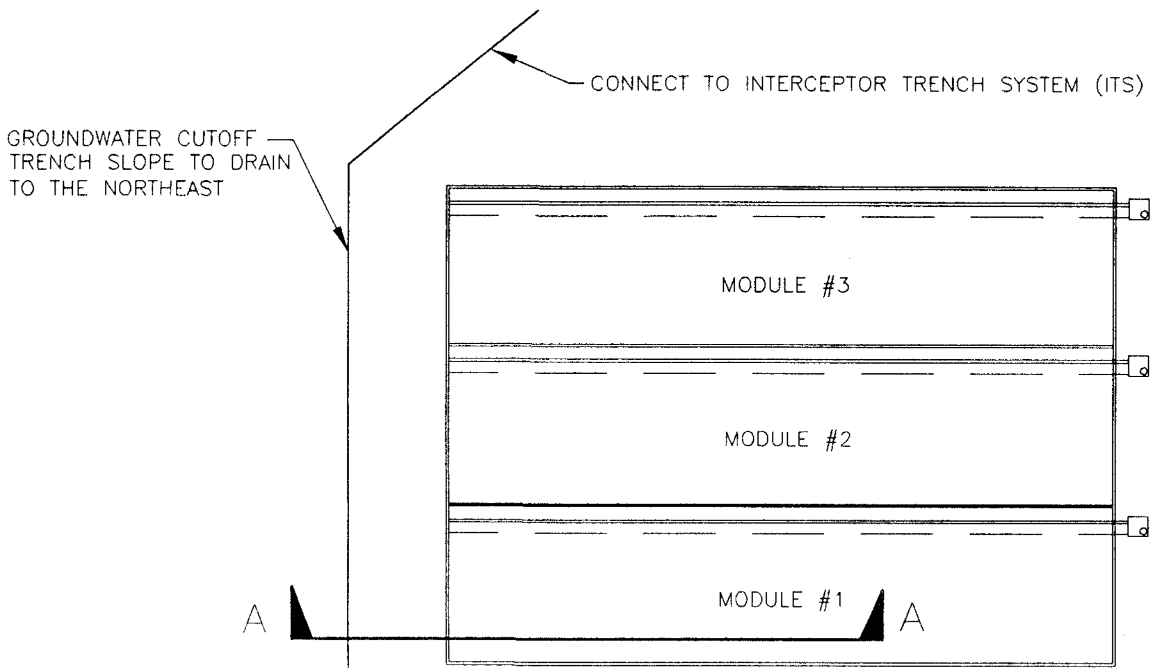
FIGURE B-4B



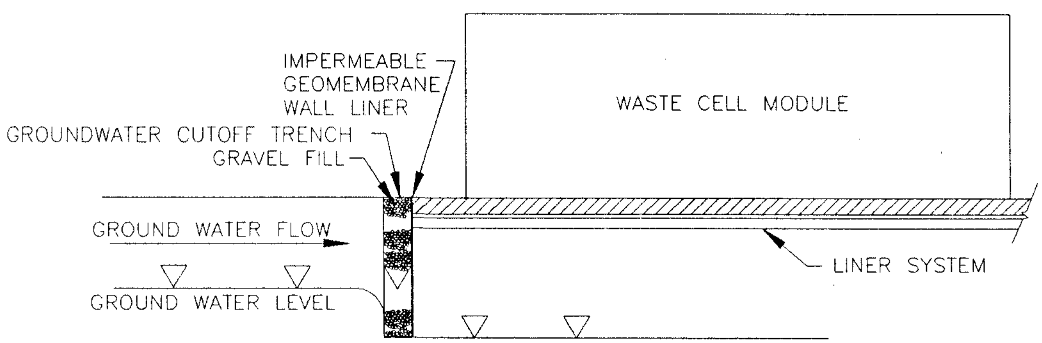
BUILDING SECTION A-A

TWIN-TEE PRECAST CONCRETE PANELS

FIGURE B-5



PLAN VIEW



SECTION A–A

FIGURE B-6

APPENDIX B-2

PRELIMINARY DESIGN NARRATIVE

CORRECTIVE ACTION MANAGEMENT UNIT FOR BULK STORAGE OF REMEDIATION WASTE

Rocky Flats Environmental Technology Site
Golden, Colorado

Prepared by
Rocky Mountain Remediation Services

for the

U.S. Department of Energy
Rocky Flats Field Office
Golden, Colorado

Preliminary Design Narrative
Corrective Action Management Unit for Bulk Storage of Remediation Waste

Table of Contents

Attachments

EXECUTIVE SUMMARY

REMEDIATION WASTE STORAGE FACILITY

The Remediation Waste Storage Facility (RWSF) will be implemented through the Rocky Flats Cleanup Agreement (RFCA), as a Resource Conservation and Recovery Act (RCRA) Corrective Action Management Unit (CAMU). It will provide on-site retrievable, monitorable storage for hazardous, low-level, and low-level mixed remediation wastes at the Rocky Flats Environmental Technology Site (RFETS). Only remediation wastes generated at RFETS will be placed in the RWSF. The RWSF will be located east of the Solar Ponds in the CAMU Designation Area shown in Figure ES-1 of the main text. The RWSF will be designed and constructed in accordance with applicable RCRA Subtitle C, Subpart N requirements, and 6 CCR 1007-3 Part 264 Subpart N .

This Preliminary Design Narrative evaluates geotechnical considerations, Preliminary design parameters, and generic specifications for the RWSF. More detailed design specification and drawings will be prepared as part of the Title II design. A more thorough evaluation of geotechnical parameters will be also be incorporated into Title II design documentation.

1.0 INTRODUCTION

1.1 PURPOSE OF PROJECT

The purpose of the Remediation Waste Storage Facility (RWSF) is to provide an on-site, retrievable and monitorable waste storage facility for low-level, low-level mixed, and hazardous waste generated by remediation activities at the Rocky Flats Environmental Technology Site (RFETS). Currently there is limited on-site storage capacity for these wastes. The RWSF will provide a new facility with the initial capacity of 100,000 cubic yards (yd^3) expandable to 300,000 yd^3 through the construction of additional cells. The facility design will accommodate the possible expansion to adjoining areas.

The scope of this project includes the design and construction of the waste cell, support facilities, and cover. The RWSF may consist of several cells within the CAMU Designation Area. The preliminary design described in this narrative would be utilized on the first RWSF cell and any subsequent RWSF cells in the CAMU designation area.

1.2 GENERAL DESIGN CONCEPT

The preliminary design presented in this narrative is for a single cell of the RWSF. A RWSF cell will have a gross capacity of approximately 110,000 yd^3 per cell to provide a net waste capacity of 100,000 yd^3 or 300,000 yd^3 for the whole RWSF complex. Each cell is divided up into three modules each holding approximately 33,000 yd^3 (see Figure B-2 of this appendix).
The waste cell will have a concrete floor and walls to limit the footprint, enhance retrievability, provide volume flexibility, and protect the liner. The waste cell will have a double liner system with leachate collection and leak detection systems.

Support Facilities for the RWSF include Building 910 which will be modified to provide office space, restrooms, locker rooms, and showers; and Building 965 which will be used for storage of operational tools and spare parts. A concrete pad waste staging area will be provided for unloading containerized waste.

A leachate transfer and storage system will be provided to manage leachate that is generated and collected in the waste cell. Only a minimal quantity of leachate will be generated during operations due to the operational enclosure. Leachate during the storage phase may result from leakage through the cover and waste consolidation. The system will transfer leachate from the waste cell to existing storage tanks located in Building 910 with a total capacity of 12,000 gallons. Leachate will be transferred by an existing pipeline to Building 374 (or the replacement Temporary Treatment Facility), or by tanker truck to the Building 891 Sitewide Treatment Facility.

1.3 GENERAL DESIGN CRITERIA

All equipment and facility sizes, capacities and ratings, etc. listed in this Preliminary Design

Narrative are preliminary, and are intended only to relay the general intent and scope of the project. Final sizing will be performed during the design phase and incorporated into subsequent submittals. All equipment will be sized to operate at the RFETS elevation of 6,000 ft above sea level. Design criteria are given in Attachment I, Preliminary Design Parameters for CAMU for Bulk Storage.

The RWSF will be designed according to the requirements of the appropriate regulatory agencies and their permit conditions. Regulatory requirements include those promulgated by the Colorado Department of Public Health and Environment (CDPHE) 6 CCR 1007-3, Part 264. The Colorado Radiation Control requirements of 6 CCR 1007-1, Part 14 do not apply to DOE facilities and will be used as guidelines only. The regulatory decision and approval process for the RWSF will be conducted as a Corrective Action Management Unit (CAMU) under the Rocky Flats Cleanup Agreement (RFCA) (DOE, 1996).

2.0 SITE CHARACTERISTICS

2.1 SURFICIAL FEATURES

2.1.1 Surface Water Features

Surface water features of RFETS include three intermittent streams, several interceptor ditches, springs, several ponds (including stormwater storage ponds), and scattered wetlands. There are no surface water features on the RWSF site itself.

The primary surface water features near the CAMU designation area (see Figure ES-1 of the Decision Document) are North and South Walnut Creek. North Walnut Creek flows into the RFETS "A" ponds and South Walnut Creek flows into the "B" ponds before flowing off-site to the east, eventually entering Great Western Reservoir.

2.1.2 Wetlands and Floodplains

Wetlands are identified on Figure 6 of Appendix C based on information provided by the United States Geological Survey (EG&G, 1994). The CAMU Designation Area is not within any 100 year floodplains based on the RFP Drainage and Flood Control Master Plan (EG&G 1992a).

2.2 SITE GEOLOGY AND HYDROGEOLOGY

A detailed discussion of the RFETS Geology and Hydrogeology is provided in the Sitewide Geosciences Characterization consisting of the following:

Volume I	Geologic Characterization Report (EG&G 1995b)
Volume II	Hydrologic Characterization Report (EG&G 1995c)
Volume III	Groundwater Geochemistry Report (EG&G 1995d)

Groundwater fluctuation within the Industrial Area of the site is dependent on the following factors:

- Vertical infiltration from precipitation events;
- Lateral migration of groundwater from, in general west to east across the facility; and
- Facility contributions to the groundwater.

Historic high levels for groundwater occurred in May and June of 1995. This period has been estimated to be the wettest in a 102 year period based upon precipitation records from Boulder, Colorado. These levels ranged from a minimum depth of 1.0 to 4.8 feet below ground surface and reflect a vertical recharge rate due to this area being an open area of flat bare ground. Vertical recharge is significantly higher in this area compared to other areas nearby. These other areas are industrial use areas significantly more impervious to infiltration due to existing structures associated with the solar ponds and 700 Area. The water levels in these areas are more representative of anticipated water levels beneath an impermeable CAMU waste storage module.

Table B-1 summarizes the groundwater data used for this evaluation. The wells were selected to be representative of conditions across the Industrial Area in close proximity or within the CAMU. Wells 43993 and P209289 are located west of the CAMU in areas with significant ground cover from buildings and roads thus limiting vertical infiltration. Wells P209789, P207889, and P207689 are located within the CAMU boundaries in areas with open flat fields that enhance "ponding" and infiltration. Well 42893 is located between Ponds 207-B South and 207-A in an area that likely represents infiltration from the ponds themselves. The standard deviations are significantly higher for wells located in open areas, suggesting that the vertical infiltration component plays the major role in influencing groundwater elevation fluctuations. This limited data set supports the conclusions that groundwater levels are, in part, dependent upon vertical infiltration and that infiltration is limited in areas with significant cover.

Table B-1 Groundwater Data from Represetive Wells in the Industrial Area of RFETS

Well number (alluvial wells)	General Location	Average Groundwater Depth (feet) (1)	Standard Deviation	Historical High Level (feet)	Casing Elevation (feet)	Surface Elevation (feet)	Historical High Depth to Groundwater (feet)
P209789	CAMU NW	8.59	2.15	5.34	5964.94	5962.8	3.2
P207889	CAMU east/central	7.3	2.14	3.97	5964.9	5962.8	1.87
P207689	CAMU SW	8.04	0.57	6.91	5967.88	5966.3	5.33
P209289	West of Pond 207-C	14.68	0.36	13.65	5983.42	5981.59	11.82
42893	West of Pond 207 -A, South of Pond 207-C	3.99	0.02	3.97	5980.35	5978.1	1.72
43993	West of 207-B South, East of 207-A	13.5	0.37	12.12	5976.39	5972.9	8.63

(1) Based on quarterly sampling data from 1989-1996

In addition to restricted vertical infiltration, gravel filled trenches constructed immediately hydraulically up gradient of the waste modules would divert lateral flow of groundwater around the RWSF module. These trenches would serve as a "cut-off" and fill with groundwater, once the groundwater reaches a certain elevation, diverting groundwater around the facility. This would minimize the potential for a significant rise in groundwater beneaththe RWSF.

One other important factor to consider is the relative contribution to groundwater from the facility itself in the form of leakage from the RFETS' water systems. Two separate water budgets developed by the USGS for 1993-94 and 1995 both show substantial contribution from RFETS to alluvial groundwater (USGS 1996, 1997). The source for this contribution is thought to be, in part, leakage from the RFETS potable and non-potable water supplies. This contribution should decrease as buildings begin to be shut down as part of site closure which should result in a decrease in groundwater levels across the site.

In conclusion, the combination of a decrease in vertical infiltration from construction of the facility and a general decrease in the site contribution to the alluvial groundwater supply from building leakage coupled with upgradient groundwater diversion will insulate the waste storage module liner systems from groundwater intrusion.Additional information on the Solar Pond site is contained in the OU4 IM/IRA Decision Document (EG&G 1995a), the OU6 RI/RFI Report (EG&G 1995e) for IHSS 165, and the OU4 Solar Ponds Phase II Ground Water Investigation (RMRS 1996).

3.0 GEOTECHNICAL EVALUATION

3.1 GEOTECHNICAL INVESTIGATIONS

Numerous boreholes and monitoring wells have been drilled at the site (see Figure 4 of Appendix C). Most of these have been installed for environmental sampling and monitoring, rather than assessment of soil properties for geotechnical design. Attachment I to the Preliminary Design Narrative provides a summary of existing geotechnical data. Geotechnical investigations performed for other projects in the vicinity of the site provided information on expected soil properties and conditions for the Preliminary Design Narrative.

3.2 FAULTS AND SEISMICITY

The closest major fault to the RFETS is the Golden Fault , which is approximately two miles southwest of RFETS. Trenching across the Golden Fault by the Colorado Geological Survey (CGS) has shown that the Golden Fault has offset the Verdos Alluvium (approximately 610,000 years in age), as well as an overlying colluvium layer (believed to be older than 70,000 years) (Kirkham and Rogers, 1981). The Golden Fault is classified by the CGS as a potentially active fault.

Other possible faults in the area include the Walnut Creek "Fault" and the Rock Creek "Fault", both identified as lineaments on aerial photographs. Drilling has indicated subsurface faulting in the Walnut Creek area, which may or may not be linked with the surface lineament feature. The Walnut Creek Fault crosses the southeast corner of RFETS and the Rock Creek feature is located approximately 1/2 mile to the north of RFETS. Additional information on faults, landslides and mining activity is provided in the Sitewide Geosciences study (EG&G 1995b) and the OU4 IM/IRA Decision Document (EG&G 1995a).

A series of bedrock faults have been inferred across RFETS, based on drill hole subsurface lithologic and geophysical logs and interpretation. One of these bedrock faults runs north-south through the Solar Ponds to the west of the RWSF (see Figure 3 of Appendix C). The inferred bedrock fault appears to be located hydraulically upgradient from the first RWSF cell location, removing the fault as a potential groundwater pathway for contaminant movement. Lithologic logs also indicate potential faulting to the west, as revealed by offset in the No. 1 Sandstone. Trenching across another of the bedrock faults north of Building 371 in the Buffer Zone showed no deformation of the Rocky Flats Alluvium across the fractured area of the bedrock. Since the Rocky Flats Alluvium is believed to be approximately 1 million years in age, it is apparent that this particular fault has not suffered movement in at least this time.

3.3 EROSION

The RWSF site is relatively flat with little evidence of severe wind or water erosion. The potential for severe water erosion during rare major storm events exists adjacent to the RWSF site near the Walnut and South Walnut Creek drainages. Adequate clearances or engineering controls will be provided to prevent unacceptable erosion of the RWSF cover. The facility will be monitored and maintained during operations and prior to shipping waste off-site to correct any erosion damage to the cover.

3.4 SLOPE STABILITY

The site for the RWSF cell is relatively flat and there is no evidence of landslides or slumps. Based on photographs from the 1994 aerial flyover, the terrain slopes to the northeast across the area of the proposed RWSF cell (See Figure ES-1 of the Decision Document). The apparent surface drainage also flows in this direction. By counting contours derived from the flyover the overall slope of the area is approximately 6 feet over a distance of 366 feet or a 1.64% slope. Figure 3 of Appendix C of the Decision document shows areas adjacent to the site with slopes of greater than 15%. The location of the RWSF cell is approximately 120 feet to the south of these areas.

Slope stability modeling was performed as part of the OU 4 IM/IRA decision document for an area in the CAMU designation area and just west of the RWSF site. Samples were collected during the OU 4 field investigation and tested for shear strength and other properties used in analyzing slope stability. The slope stability was then modeled using Version 5 of the XSTABL program developed by I.S. Designs, Inc. of Moscow Idaho. This model utilizes a two-dimensional limit equilibrium analysis to determine the critical failure surface of a given slope. A design life of one thousand years was used in this model. The critical section analyzed was the area north of the Solar Ponds running north to North Walnut Creek. The XSTABL was then used to calculate safety factors against slope failure. The analysis concluded that the calculated safety factors were adequate in comparison to published values for earthen embankments. This study was conducted in an area with the same geology but much steeper slopes and over a much longer design life than that proposed for the RWSF. Stability analyses of slopes potentially impacting the stability of the RWSF will be performed during the design phase.

3.5 SWELLING SOILS

The Arapahoe and Laramie Formations contain expansive clays (Van Horn, 1976), which have the potential to damage the RWSF over time. The presence of expansive clay within the Rocky Flats Alluvium is highly variable. Bedrock samples at the RFETS Sewage Treatment Plant swelled 1.2% to

6.8% when wetted under a 500 psf surcharge (GTG-Fox, 1995). Bedrock samples at the Temporary Modular Storage Tanks swelled <0.25% to 10.8% when wetted under a 1000 psf surcharge (Woodward-Clyde, 1991). The bedrock swell potential for boring 44093 in the CAMU designation area is "high" based on the Atterburg limits (Coduto, 1994), reference Figure B-1 southwest corner of module 1 for the boring location. Also reference Figure II.2-12, OU-4 IM/IRA EA Decision Document.

The weight of the RWSF cell should offset some expansion of the clay, due to the confining pressure induced by the weight of the facility. There will always be at least four feet of soil on top of the clay bedrock with the clay liner and gravel drainage layer. The presence of moisture is a primary factor in soil swelling. Construction of the RWSF will reduce on-site infiltration, which will reduce the amount of water accessible to the claystone under the cell. This could cause additional settling in area due to dewatering of the clays. There is no evidence of damage from expansive soils to Building 964, which is located in the CAMU designation area. The building was constructed in 1986 using a slab-on-grade foundation. The geotechnical investigation for the RWSF will include testing the bedrock for swell potential. This investigation will be performed as part of the design phase. Potentially expansive clay bedrock should not effect the waste cell design.

3.6 BEARING CAPACITY

The bearing capacity of the soil must be greater than the maximum loading of the facility. The estimated maximum loading from the RWSF is 3,200 psf. The bearing capacity of the RWSF site is estimated to be a minimum of 4,000 pounds per square foot (psf). The facility rests on the Rocky Flats Alluvium which is 5-20 feet thick at the RWSF site and consists primarily of clayey sands and gravels. Based on the Uniform Building Code for these soil classifications, the bearing capacity is estimated to be 4500 psf. A rough approximation of the bearing capacity of the alluvium based on the Standard Penetration Test blow count is 6,800 psf.

Underlying the alluvium is bedrock comprising of claystone and sandstone with the top 5-10 feet being highly weathered. The calculated bearing capacity for the top, highly weathered portion of the claystone bedrock is 4,260 psf. The calculated bearing capacity of the deeper less weathered claystone bedrock is 12,260 psf, the claystone values are based on triaxial sheer tests performed for the OU 4 IM/IRA Decision Document (EG&G, 1995a).

A geotechnical investigation will be performed as part of the Title II design to provide an accurate determination of the soil bearing capacity. One additional factor that will have to be evaluated during the Title II design is the bearing capacity and settlement of the 3-foot compacted clay liner. Without this investigation, a minimum value of 4,000 psf should be assumed based on existing geotechnical data and geotechnical investigations for other sites with similar geology at RFETS. Based on this preliminary evaluation the bearing capacity is greater than estimated maximum loading and therefore capable of supporting the RWSF cell.

3.7 SETTLEMENT

The primary concern with settlement is that differential settling could compromise the integrity of the liner system, the concrete modules or the cover. Because of the facility type, the RWSF cell would not be particularly sensitive to uniform settlement; however, excessive differential settlement could lead to liner penetration. The determination of quantitative values for settlement requires additional test data and knowledge of the distribution of subsurface materials. Materials susceptible to settlement include the clay liner itself and clay/silt fraction present in the Rocky Flats Alluvium and the weathered bedrock. The unconsolidated alluvium could also contain lenses or stringers of sand and/or clay. Consideration of bedrock consolidation properties is appropriate because the bedrock consolidation will likely affect settling since the large size of the structure results in greater loads as a function of depth and also because the alluvium is relatively shallow. The depth to bedrock in the area of the RWSF is about ten to twenty feet (see Figure 5 of Appendix C). The relatively thin layer of unconsolidated material combined with the shallow depth of bedrock should impede settling.

The Consolidation Test Data Table (from Borehole 54594) gives values for the compression index, recompression index, initial void ratio, unit weight, and preconsolidation pressure for a single borehole in the area of the RWSF. Based on the consolidation test data and settlement calculations (McCarthy, 1988) the settlement was calculated to be 3.4 inches indicating that little settlement would occur primarily because the tested soil was already very consolidated. In calculating the settlement, it was assumed that bedrock did not impact settling. As a worst case assumption it was assumed that there was 19 feet of alluvium and that all of the alluvium was composed of fine grained material (clay).

Based on preliminary information, the selected site appears to be well suited for this facility and unacceptable settlement is not expected since,

- The soils have been preconsolidated.
- The bedrock is close to the surface.
- It is expected that the bedrock is consolidated and the RWSF will result in little additional settlement.

Additional geotechnical investigation data gathered before the Title II design phase should provide the necessary information so that the bedrock settlement and the total differential settlement can be predicted.

4.0 PRELIMINARY DESIGN

4.1 DESIGN PARAMETERS

The preliminary design parameters for RWSF were incorporated as integral part of the preliminary design process. At the request of the CDPHE, a table of design parameters has been provided as Attachment I to this narrative. This table was adapted from the *Proposed Corrective Action Management Unit Decision Document for the Rocky Mountain Arsenal, Commerce City, Colorado, January 12, 1996* (Harding Lawson Associates, 1996).

4.2 SITE WORK

4.2.1 Utilities Preparation

A fire hydrant will provide water for compaction and dust control. Primary electric power will be derived from the existing 13.8 kilovolt-amperes aerial lines located immediately south of the RWSF site. Secondary power for the office areas and shower facilities will be derived from the existing Building 910 distribution center.

4.2.2 Earthwork

The RWSF will be designed to preserve and protect existing vegetation and other features on or adjacent to the site that do not unreasonably interfere with construction. The design drawings prepared for the Title II Design will identify staging and stockpiling areas within the CAMU. The grading design will provide existing and new contours, and spot elevations shown at grade changes and structure elevations. Cross sections will be provided where practical and where earthwork quantities are substantial. The Title II Design will specify appropriate compaction requirements for approved material, moisture requirements, and general placement methods.

4.2.3 Site Access and Security

Since the site is located inside the PA, special access will be required for construction. A new entrance to the PA will be constructed at Portal 3 to allow trucks to access the site without full inspection, and to provide access for uncleared construction personnel. The RWSF site will be separated from the rest of the PA to permit uncleared construction personnel with limited escort guards.

Roads will generally be designed to conform to the Colorado Department of Transportation (CDOT) Roadway Design Manual-Section 1100 (Off System and Low Volume Roadways). Thickness design for aggregate base course and pavement will be in general accordance with the CDOT Roadway Design Manual.

4.2.4 Landscaping

Seeding with a proper mixture of grasses or other plant material will be required for disturbed and bare areas, to provide erosion control and water conservation in accordance with the Soil Conservation Service requirements. Plant material will be selected as proven to be hardy in semi-arid climate adaptable to the RFETS area. Plants will be only shallow rooted varieties to prevent penetration of cover materials. Landscape stone may be used as ground cover in areas where live vegetation ground cover is undesirable.

4.2.5 Site Drainage

A Drainage and Erosion Control Plan, and a Reclamation Performance Standard will be prepared during Title II design for construction, operation, and closure of the facility. A site drainage study for each phase of RWSF development will be prepared using the appropriate methods presented in the Denver Urban Storm Drainage Criteria Manual, Jefferson County Storm Drainage and Technical Criteria manual, and RFETS Standard SC-109, "Storm Sewer Design Criteria." Site drainage will be designed to accommodate the storm water as determined in the drainage calculations. Drainage must be designed to not allow flooding of the waste cell from the 100-year, 24-hour event. All drainage analyses shall use data from previous studies conducted for the RFETS where possible and appropriate (EG&G, 1992b and ASI, 1991). These studies shall be verified for adequacy for the intended use.

Erosion control on steep slopes (defined as a 3:1 slope or steeper) will be provided with erosion fabric seeded with native grasses, rip rap surface, gravel surfaces, hard surface paving, or other approved methods to prevent erosion. Erosion control of other areas will be provided by use of silt fences and hay bales per CDOT design criteria.

4.3 WASTE CELL

4.3.1 Cell Description

The preliminary site plan and cell layout is shown on Figures B-1 and B-2 at the front of this appendix. The cell is 360 ft. wide by 500 ft. long. The cell consists of three 120 ft. wide modules. The outer walls of the cell are 14 ft. high while the inner walls are 18 ft. to provide a 3% minimum slope for the earthen cover option. Twelve feet of fill at a 2:1 slope will be placed around the outer walls to provide structural support and provide frost protection for the compacted clay liner. The capacity of the two outer modules is 34,500 yd^3 each, while the inner module is 41,000 yd^3 giving a total gross capacity of 110,000 yd^3. The RWSF preliminary design is modular to facilitate future expansion. Several options are to be considered as the cover for the cell. The proposed option, an earthen cover, shown on figures 7-2 and 7-3 of section 7.2 was the option used in developing the cost for a cover. The following three cover options are described in detail:

- Metal Roof Deck - This option would be similiar to a standard metal building. The inner and outer walls could be constructed at the same height, fourteen (14') feet, with deep long-span steel joists bearing on each wall and spanning the module width. A baked enamel steel deck would be fastened to the steel joists, reference figure B-4. Because of the long span, one hundred twenty feet (120') deeper steel joists would be required unless a row of column supports were constructed at midspan which could reduce the steel truss depths. A reduction of the net volume capacity for the cell is affected in using deep steel joists. The metal roof would be designed for the appropriate dead and live loads discussed under section 4.6.

- Precast Concrete Panels - This option utilizes twin-tee precast concrete panels to span the module width. Placed over the concrete, a urethane or built-up roof would be required to provide an impervious barrier, reference figure B-5. Similiar to the metal roof option, because of the long span, the webs of the twin-tee panels would be deep and may require intermediate column supports at the midspan. A reduction of the net volume capacity for the cell is realized using deep twin-tee precast panels. The precast concrete panels would also be designed for the appropriate dead and live loads.

- Vegetative Earthen Cover - This option was described in section 7.1 and was the basis for estimating the cover cost. The vegetative earthen cover would be supported by the consolidated waste in each module wether bulk or containerized. Approximately two feet thick consisting of a vegetative cover, drainage layer, and a geosynthetic membrane.

The finished grade of the cover would be sloped 3% - 5% to promote drainage

The liner system consists of two liners, a leak detection system, and a leachate collection system. The cell will be placed abovegrade, with the top of the liner system located approximately at the existing grade. The actual depth of the liner system is dependent on both the need for frost protection and the need to maintain separation between the liner system and the groundwater table. The depth of excavation will be determined in the Title II Design where these design elements will be evaluated more rigorously. A combination of engineering barriers and facility design criteria will be used to maintain separation between the groundwater table and the liner system. Gravel filled trenches (e.g., french drain) will be installed hydraulically upgradient of the cell to minimize lateral infiltration of ground water. The trenches will gravity flow to the northeast.

The following remediation waste streams will be accepted at the RWSF:

- Investigation Derived Materials (IDM) in drums.
- Low-level mixed waste in boxes, drums or containers.
- Bulk remediation wastes such as soils and sludges.
- Demolition debris from remediation activities..

Average placement rates are estimated to be 250 yd^3 per day. Maximum placement rates are estimated at 500 yd^3 per day. All waste will be prepared for placement and will meet the RWSF Waste Acceptance Criteria (WAC) prior to transport to the RWSF. No waste processing will be done at this facility. All waste will be placed directly in the cell. A staging area will be provided for unloading of containerized waste.

Bulk wastes will be compacted after placement in the cell. Waste that must be kept in containers and decommissioning/demolition debris with void space, will be placed in separate compartments from the bulk waste. This compressible waste will require filling of void spaces with soil or grout to provide structural support only for the earthen cover option. Waste in drums or containers may require removal from the container or compaction of entire container during placement in order to meet the WAC.

Waste placed in the RWSF will be recoverable. Grid markers will be located around the perimeter of the cell. A controlled survey point will be installed as a basis for this grid-block mapping. Cell grids will be established for both the horizontal axes and the vertical (elevation) axis. Compartments will be provided where required to segregate waste types.

4.3.2 Cell Structure

The waste cell will have a concrete floor and walls (see Figure B-3 at the front of this appendix). A RCRA double liner system will be provided below the floor. The waste and clean-fill berms will provide structural support for the cap. The floor slab will be required to withstand static and dynamic loading from fill and equipment. Alternative methods of designing the retaining walls and floor slab will be evaluated during Title II design.

Twelve feet of vegetated fill at a 2:1 slope will be placed around the perimeter of each module to provide structural support and provide frost protection for the compacted clay liner. The fill will not be placed at the bottom access doors. The fill along the north side of Modules 1 and 2 will require removal during construction of the next module.

4.3.3 Liner System

The cell will be designed with a double liner system. The liner will comply with "RCRA Subtitle C" requirements as defined in 6 CCR 1007-3, Part 264 and 6 CCR 1007-2, Part 2. The liner and leachate collection system (Figure 7-3 of the Decision Document) used in the cell will consist of, from the bottom upward:

- A bottom (secondary) composite liner incorporating 3 ft of compacted clay overlain by an 80-mil geomembrane.

- A geonet leak detection system, including geotextiles above and below the geonet.

- A top (primary) liner consisting of an 80-mil geomembrane with an overlying protective geotextile.

- A leachate collection system consisting of a 12-inch minimum gravel layer below the concrete floor and a trench drain for each module cast into the floor which will not comprimise the integrity of the concrete floor. In between the gravel layer and concrete will be a separation barrier to prevent the concrete from filling the void space in the gravel.

Hay bales or an approximately two-foot-thick layer of waste or clean soil will be required to provide frost protection for the clay liner. It waste is used, a geotextile or a thin layer of clean fill may be required above the waste layer to provide an uncontaminated surface for vehicles and to control dust. As an alternative, hay bales might be placed in the unused portion of the cell during the winter to provide frost protection. The frost protection requirement will be most difficult to meet for the compartments used for containerized and decommissioning/demolition waste. Frost protection of the clay liner will also be required at the cell access doors and leachate/leak collection sumps. The design frost depth will be determined during Title II design using the methods developed by the Cold Regions Research and Engineering Laboratory (Aitken and Berg, 1986).

A clay liner test fill will be constructed and evaluated prior to construction of the cell clay liner. The testing requirements and plan of construction will be defined in the Construction Quality Assurance (CQA) Plan which is developed in parallel with Title II Design. Title II plans and specificationswill be approved by the CQA engineer.

4.3.4 Leachate Collection System

The leachate collection system located below the concrete floor will minimize the depth of leachate on the primary liner during the operation and storage period by removing liquids. The system will keep the buildup of leachate hydrostatic head to less than one-foot above the primary liner. A drainage trench with filtered grating will be installed above the concrete floor to convey leachate to the sump. A slotted collection pipe will be installed in the gravel drainage layer below the floor to carry the leachate to the sump area. A submersible pump will be installed in the leachate collection sump.

4.3.5 Leak Detection System

The leak detection system will allow for detection, collection, and removal of liquid that leaks through the primary liner. The system will consist of a geonet below the primary liner and above the secondary liner. The leak detection system will drain to a sump with a submersible pump. A liquid level sensor will connect the system to a control panel in the office of Building 910. A portable, submersible pump will be used to removed any accumulated liquids if leakage is detected in the leak detection sump. Detected liquids will be pumped into the leachate storage tanks. The removal system will measure the volume of liquid removed with an in-line totalizer. The pump will be designed to operate manually.

The Action Leakage Rate (ALR) will be determined for the liner systems in accordance with 6 CCR 1007-3, Part 264.302 and EPA guidance. The rate will be determined for each module and will be used in the development of a Response Action Plan (RAP).

4.3.6 Liner Compatibility

Chemical compatibility testing will be conducted for liner, leachate collection system, and sump materials during Title II design. A decision flow diagram for liner compatibility is provided under Appendix B-3 section 3.6. A preliminary estimation of the leachate composition is provided in Appendix G of the Decision Document.

4.3.7 Cell Operations

Access and Waste Placement

Access will be provided to each module compartment by a ground-level doorway (See Figure B-1 at the front of this appendix). Bulk waste will be emptied from dump trucks or roll-off containers from the top of the module. Containers, non-size-reduced demolition debris, and structural steel will be placed in the compartments from the bottom with fork trucks or other equipment. A crane or lift will be required for top placement, if necessary. The waste will be placed without compaction. If segregation is not required, these non-compactable wastes will be co-placed with bulk waste to fill any voids and minimize settlement. The procedure for waste placement will be finalized during the Title II design.

Operational Enclosure

An operational enclosure will be placed over the module during the operations phase. Considerations include carbon monoxide build up and run-off control. The feasibility of various types of operational enclosures will be evaluated during the Title II design.

Dust Suppression and Daily Cover

Bulk waste will be moist during unloading to minimize dust emissions. Normally, the waste will be moistened during excavation for dust suppression. If necessary, additional dust control measures will be utilized such as a hand-held water hose, spray curtain, or chute. The amount of water added will be controlled to minimize leachate generation and avoid creation of too-wet-to-compact soil.

With the operational enclosure, daily cover will not be required to prevent wind dispersal of bulk waste. Fugitive dust emissions will be controlled with water. If additional protection is required, either a spray-on or geosynthetic alternative daily cover will be used to control dust emissions and the spread of contamination.

4.3.8 Cell Cover

The selected cover option would be installed after completing waste placement if offsite disposal is not readily available. If offsite disposal is readily available the operational cover will remain in place until the module is emptied. The cover will be installed to limit infiltration and prevent dust dispersal. The three design options are a metal deck roof, precast concrete panels twin-tee, or an earthen cover. The metal deck as explained earlier would be long span steel joists which span the module and a baked enamel metal deck fastened to the joists. Further analysis will compare the need for intermediate column supports to shorten the clear span and utilize shallower steel joists. The second option, precast concrete twin-tee panels, are similiar with the long clear span support, one hundred twenty feet. Intermediate column support would allow shallower webs or joists on the twin-tee beams. The earthen cover option will be sloped 3 to 5% over the top of the facility to promote drainage. The cover can be installed over individual compartments or even portions of compartments when filled with waste. The operational enclosure will be removed once the cover is installed on the entire module. The earthen cover option will be maintained to repair any damage.

The earthen cover (see Figure 7-3 of the Decision Document) will consist of from the bottom up:

- Protective geotextile.
- 60-mil geomembrane.
- Geonet composite with geotextile on both sides.
- 2-ft of common fill and topsoil with vegetation. 6-in of aggregate base coarse will be placed in areas for vehicle access to adjacent modules.

Non-compacted waste such as containers and decommissioning/demolition debris will be infilled with sand prior to installation of the cover. Sand must be placed in lifts along with the waste to ensure all voids are filled. In order to minimize settlement, containerized waste should be removed from the containers, and demolition debris should be size-reduced prior to placement.

4.4 LEACHATE MANAGEMENT

4.4.1 Leachate Generation

The RWSF run-off management system will be designed to collect and and control at least the water volume resulting from a 24-hour, 100-year storm. The RWSF run-on management system will be designed to prevent flow onto the active portion of the facility during peak discharge from at least a 100-year storm. All water that falls within an operational module and potentially comes in contact with waste will be collected as leachate and transferred to the leachate collection system. Only minimal leachate will be generated during operations and storage, due to the operational enclosure and the cover.

Leachate production will be assessed using the latest version of the Hydrologic Evaluation of Landfill Performance (HELP) computer program. The HELP modeling will be performed using RFETS climatological data. Based on preliminary HELP modeling, the average leachate generation is expected to be less than 250 gal/year.

Without the operational enclosure, the leachate collection system would have to be designed for the 24-hour, 100 year storm, which results in 194,000 gal of run-on for one module. The estimated leachate generation would be 268,000 gal/year assuming a 50 percent loss due to evapotranspiration and retention in the waste.

4.4.2 Leachate Transfer and Storage

A leachate transfer and storage system will be provided to manage leachate that is generated and collected in the cell. This system will transfer leachate from the waste cell to two existing storage tanks in Building 910. Leachate will be transferred from the storage tanks to a treatment system at RFETS by an existing pipeline or a tanker truck. The leachate storage tanks and ancillary equipment will have secondary containment meeting the requirements of 6 CCR 1007-3. Electric heat trace for freeze protection will be required for all outdoor above-grade piping, pumps, and ancillary equipment. All areas where leachate is transferred will be contained to prevent spills.

4.4.3 Leachate Treatment

RFETS currently has two facilities for the treatment of low-level mixed waste leachate; the Building 374 Liquid Waste Treatment Facility and the Building 891 Sitewide Treatment Facility. The Building 910 leachate storage tanks will permit sampling prior to treatment.

Building 891 has the capability of treating the anticipated leachate, which could contain organics, heavy metals and radionuclides. The maximum treatment capacity is 30 gallons per minute. Building 891 is equipped with a tanker truck unloading station and 30,000 gallons of influent storage capacity.

Building 374 can treat water metals and radionuclides. However, the Building 374 processes do not treat organic contaminants. Since soils with high concentrations of organic contaminants will be treated by thermal desorption prior to placement in the cell, the leachate should contain only small concentrations of volatile organic compounds.

4.5 SUPPORT FACILITIES

The RWSF will operate one shift per day, five days per week. Outdoor illumination at the support facilities will be provided for potential nighttime operation. Portable illumination will be furnished when nighttime work is conducted in the cell. It is estimated that up to 10 people will be working at the RWSF.

1 - Supervisor
6 - Waste Technicians
2 - Equipment Operator
1 - Radiation Control Technician

4.5.1 Personnel Facilities

Building 910 will be modified to provide locker facilities, a personnel protective equipment dress-out area, shower facilities, office/break space, and an area for measuring and testing equipment. If Building 910 is not available for these purposes, a similar building will be used or constructed.

4.5.2 Equipment Decontamination

Equipment decontamination will be provided by the existing PA Decontamination Pad. The Decontamination Pad will require removal or relocation prior to the construction of Module #3 of the cell.

4.5.3 Waste Staging Area

A waste staging area will be provided for truck unloading, short-term storage of waste prior to placement in the cell, and storage of non-compliant waste prior to return to the originator. The staging area will be a bermed concrete pad. The Staging Area will comply with the requirements of 6 CCR 1007-3, Part 264, Subpart I. Precipitation and spills will be collected in a sump. A portable pump will be used to remove liquids for treatment, or release is determined to be non-contaminated.

4.5.4 Storage Area

Building 965 will be used for storage of spare parts and other miscellaneous items. The building will not require modification.

4.6 STRUCTURAL DESIGN CRITERIA

The waste cell and support facilities are "Performance Category 1" in accordance with DOE-STD-1021, "Natural Phenomena Hazards Performance Categorization Criteria for Structures, Systems, and Components." The structural design will meet the requirements of the UBC and DOE-STD-1020, "Natural Phenomena Hazards Design and Evaluation Criteria for Department of Energy Facilities." The loads used in the structural design of buildings and other structures will comply with of ASCE 7, "Minimum Design Loads for Buildings and Other Structures."

Dead loads: Include the weights of all permanent materials and equipment supported in or on the structure (e.g. concrete, remediation waste, cover option, etc.) including the structure's own weight and other permanent static loads.

Live loads: Include floor and roof area loads (e.g. snow and rain loads, personnel and furniture, vehicular heavy equipment), and impact loads (e.g. overhead traveling cranes, etc.)

Snow Loads: Minimum snow load will be 43 psf at ground level applied in accordance with ASCE 7.

Wind Loads: Wind load design will be in accordance with ASCE 7 with a basic wind speed of 109 mph. Exposure "C" will be used for all construction and the importance factor is 1.0.

Seismic Loads: Structures, equipment and tanks will be designed in accordance with the UBC and RFETS Standard SC-106, "Equipment Seismic Qualification."

4.7 SITE ELECTRICAL

4.7.1 General

Drawings generated during the Title II design phase will identify underground services and provide plan view dimensioning of service runs with locations of manholes, splice boxes and other pertinent features associated with them.

4.7.2 Power Supply

The Title II Drawings will detail the tapping of the existing 13.8 kV aerial line for providing a feeder to the pad mounted 13.8 kV-480Y/277 V, three phase, four wire transformer.

4.7.3 Illumination

Illumination levels will be determined from applicable tables in the latest edition of the Illuminating Engineering Society (IES) Handbook for interior and exterior lighting. The energy conservation measures recommended in DOE Order 6430.1A and ASHRAE Standard 90 shall be incorporated where cost effective.

4.7.4 Grounding

Appropriate grounding conductors shall be routed within all power conduits. Conduits shall not be relied upon for ground continuity. Lightning protection will be provided on the roof of buildings per NFPA 780 and NFPA 70.

4.8 ALARMS AND COMMUNICATIONS

4.8.1 Fire Alarms

Fire protection and detection will conform to DOE Order 5480.7A, NFPA 72 and RFETS Standard SF-100, "Fire Protection." Building 910 currently has fire alarms and a sprinkler system. All modifications shall comply with NFPA 101, "Life Safety Code". and other applicable NFPA and RFETS standards.

4.8.2 Life Safety/Disaster Warning (LS/DW) System

A plant warning system, referred to as LS/DW is already installed in Building 910. Radio communication will be used for operators at the waste cell.

4.8.3 Instrumentation

Instrumentation and control requirements for the RWSF will consist of level controls, pressure indicators, pump controls, temperature indicators and controls, and leak detection. Sump leak detection will consist of gravity feed pipe sloped towards the sump to collect liquids. This liquid will be detected by a moisture detection system installed in the sump and will provide an alarm to alert operations personnel of a leak.

4.9 ENERGY CONSERVATION

An Energy Conservation Analysis (ECA) is not required since there are no new buildings but good faiths efforts will be made in the design to conserve energy.

4.10 OPERATIONAL EQUIPMENT

Rolling stock and heavy equipment will be required for operation of the RWSF. It is anticipated that this equipment will be dedicated to this facility. An initial preliminary list of equipment, some of which may already be available at RFETS, is provided below:

Compactor with blade (i.e. sheepsfoot) - to compact bulk waste in the cell
Front End Loader - to handle bulk waste
Forklift - to unload drums and/or boxes of waste
Water Truck - for compaction and dust suppression

A vibratory compactor may be required for tight spaces and infilling sand in containerized and D&D waste.

4.11 OPERATIONAL SEQUENCE

Remediation waste will be generated at various locations within RFETS. Bulk waste will arrive at the RWSF in dump trucks covered with tarps or in roll-off containers. The operational equipment will be used to handle and compact the waste inside the cell. The transport trucks will require survey prior to leaving the site. If decontamination is required, the trucks will go to the adjacent PA Decontamination pad for washing and survey. Containerized waste will be unloaded at the Waste Staging Area. Transport trucks will generally not require decontamination. The containerized waste will then be transferred to the cell by the operational equipment. Containerized waste will either be emptied from the container in the cell and compacted, or the container and contents will be compacted together after placement in the cell. Containerized waste should not sit at the Waste Staging Area for more than one shift.

4.12 SAFETY CONSIDERATIONS

The design and construction accomplished on this project will conform to DOE Order 5480.4. Radiological controls will be based on the RFETS RadCon Manual. It is assumed the cell will be considered a "Contamination Area". The National Fire Code and NFPA Code 241, "Safeguarding Building Construction and Demolition," DOE Order 6420.1A, RFETS HSP Manual and CFR 29 (OSHA 1926 and 1910) will apply to work on this project during construction and operations.

5.0 QUALITY ASSURANCE

The System Category Levels for this project based on COEM-DES-223 are 3 and 4.

Category 3 -relied upon for worker protection from radiological or toxicological hazards; required for protection of Special Nuclear Materials; required for site response in an emergency; or provide automatic fire suppression or detection capability. The following systems for the RWSF are System Category 3:

1. LS/DW System for the office and shower trailers,
2. Leachate collection, transfer and storage system.

Category 4 - systems not meeting the criteria for Categories 1, 2 or 3. All other systems including the waste cell are System Category 4.

5.1 APPLICABLE CODES, STANDARDS, AND GUIDELINES

A preliminary list of applicable codes, standards and guidelines has been generated and has been attached to this Preliminary Design Narrative as Attachment III. This list will be further modified as part of Title II design.

5.2 REQUIREMENTS AND SPECIFICATIONS

Copies of specifications for key elements of the preliminary design have been attached to this Preliminary Design Narrative as Attachment IV. These are preliminary specifications. Changes in plant specifications or as part of the design process will be incorporated into the Title II design documentation.

6.0 REFERENCES

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Attachments to Preliminary Design Narrative for the Corrective Action Management Unit for Bulk Storage of Remediation Waste

Attachment I - Preliminary Design Parameters for CAMU for Bulk Storage

Attachment II - Geotechnical Data

Attachment III - Preliminary List of Applicable Codes, Standards, and Guidelines

Attachment IV - Key Material Specifications and Requirements

ATTACHMENT I - Preliminary Design Parameters for CAMU for Bulk Storage

Design Item	Component	Performance Standard[1]	Design Guidance[3]	Design Parameter Demonstration[3]	Resultant Design Criteria[4]
1. Layout of RWSF CAMU Designation Area	RWSF layout and size	Provide for flexible facility expansion within CAMU designation area. Provide compatible scheduling of module capacity versus waste generation rates and offsite disposal capabilities. Maintain separation between the groundwater and the liner system.		Technical feasibility and review of layout concepts by the parties, followed by detailed design analysis of the selected layout configuration.	To be determined following design analysis.
2. Foundations	Site Geology / Engineering Characterization			Geotechnical index parameters, geological profiles, representative construction drawings (plans and specifications)	
	Settlement (total and differential)	Prevent failure of RWSF containment system/ clay liner and other components from subsidence		Engineering analysis	Allowable settlement to be selected following analysis.
	Bearing Capacity	Prevent failure of containment system/ clay liner and other components from loading		Engineering analysis	To be selected following analysis.
	Potential for Excess Hydrostatic Pressure	Prevent failure due to hydrostatic pressure.	Evaluate hydrostatic pressure caused by groundwater or infiltration of surface water as applicable.	Engineering analysis	To be selected following analysis.
	Seismic Considerations	Structures will withstand seismic stress.	ASCE 7, UBC and DOE-STD-1021 are applicable design standards	Engineering analysis	To be selected following analysis.
	Slope Stability	Prevent failure of containment /liner system	Proven past practices and ASTM standards.	Engineering analysis	To be selected following analysis.
	Structural Strength	RWSF must be of sufficient strength to support waste contents and prevent failure due to physical conditions of daily operations.	6 CCR 1007-3, ACI, AISC, and ASTM standards and requirements as well as past practices for concrete foundations.	Engineering analysis	To be selected following analysis.

ATTACHMENT I - Preliminary Design Parameters for CAMU for Bulk Storage

Design Item	Component	Performance Standard[1]	Design Guidance[3]	Design Parameter Demonstration[3]	Resultant Design Criteria[4]
3. Liner System	Composite liners (general)	Reduce potential for contaminant transport from the modules, and designed to maintain leachate at a depth less than one foot over the liner. Provide natural and synthetic materials that are compatible with expected waste-generated leachate	6 CCR 1007-3 264. 300 , Subpart N - Landfill and Title II design	Standard practice, engineering analysis, and compatibility testing.	The total cumulative thickness of the multiple liner system will be a minimum of four feet thick. Two barrier systems, primary barrier - 80 mil geomembrane and the secondary barrier - a composite layer consisting of an 80 mil geomembrane overlying 3' thickness of CCL
	Concrete Infrastructure	Minimize potential settlement or subsidence and reduce thermal expansion and contraction.	ACI/ASTM codes and standards and past concrete practices	Standard practice, engineering analysis, and compatibility testing	Criteria to be selected during Title II Design, (e.g. slab thickness, reinforcement details, types of joints and their spacing, etc.)
	Separation Barrier	Provide and act as a barrier between the concrete slab and leachate collection system.		Engineering analysis	To be selected following analysis.
	Primary Barrier - 80 mil geomembrane	Chemically compatible with waste or leachate, and sufficient strength to prevent failure from stresses of daily operations, installation, or pressure gradients (264.301)	6 -CCR -1007-3 264.300, Subpart N - Landfills and past practices of landfill projects	Confirmation of compatibility to be determined during Title II Design phase. Confirmation of material properties for geomembranes are identified under Title II design.	Criteria to be selected during Title II Design.
	Secondary Barrier - Composite liner (80 mil geomembrane with 3' CCL)	Chemically compatible with waste or leachate, and sufficient strength to prevent failure from stresses of daily operations, installation, or pressure gradients (264.301)	6 -CCR -1007-3 264.300 Subpart N - Landfills and proven past practices at landfill projects	Confirmation of compatibility to be determined during Title II Design phase. Confirmation of material properties for geomembranes are identified under Title II design.	Criteria be selected during Title II Design, (e.g. compaction and moisture content requirements)
	Borrow/clay liner material	Chemically compatible with leachate and has a hydraulic conductivity $\leq 1 \times 10^{-7}$ cm/sec	6- CCR - 1007-3 264.300, Subpart N . Geotechnical index parameters for the clay material will fall within a range and considered by the test fill analysis	Index testing. Test fill analysis for conductivity, constructibility, water content alterations, scarification requirements, and methods of amending soil if required. Engineering analysis of bearing capacity, settlement, and slope stability, compatibility testing, and evaluation.	To be selected following analysis.

ATTACHMENT I - Preliminary Design Parameters for CAMU for Bulk Storage

Design Item	Component	Performance Standard[1]	Design Guidance[3]	Design Parameter Demonstration[3]	Resultant Design Criteria[4]
	Subgrade Preparation	Provide a stable foundation capable of providing support to the liner system and resistance to pressure from above and below the liner to prevent system failure due to settlement, compression, or uplift.	Evaluate the potential for hydrostatic failure. Develop, if necessary, methods to prevent foundation failure due to excess hydrostatic pressure during construction and waste placement. Provide a suitable subgrade free of soft spots, organics, or unsuitable materials. Subgrade evaluations will be performed. Methods such as proof rolling, visual observation, or soils mapping may be employed. Abandoned wells and borings should be addressed to remove potential migration pathways. Recompacted backfill should be placed to provide a surface with adequate settlement and bearing capacity properties.	Engineering analysis of settlement, bearing capacity, buildup of hydrostatic pressure, and suitability of subgrade materials.	To be selected following analysis.
4. Leachate Collection Systems (LCS)	General	Maintain less than one foot of leachate on the underlying liners throughout operations and closure. Prevent failure of the LCS due to settlement, loading, waste incompatibility, and clogging throughout active life.	6-CCR -1007-3 264.300, Subpart N - Landfill requirements and control clogging.	Engineering analysis. Chemical compatibility evaluation and testing of leachate collection system components to demonstrate long term performance.	Criteria be selected during Title II Design.
	Floor Slab Trench Drain Collection System	Leak Collection System must be appropriate for physical and chemical compatibility characteristics of waste and remain clog free	Prevent clogging through design standards and self flushing with adequate flow velocities	Confirmation of compatibility to be determined during Title II Design phase.	Criteria be selected during Title II Design.
	Leachate Collection System, synthetic material	Maintain less than one foot of leachate on the immediate underlying geomembrane.	Use of a geotextile to prevent silting. Use of a geonet with a transmissivity within design specifications.	Engineering analysis.	To be selected following analysis.

ATTACHMENT I - Preliminary Design Parameters for CAMU for Bulk Storage

Design Item	Component	Performance Standard[1]	Design Guidance[3]	Design Parameter Demonstration[3]	Resultant Design Criteria[4]
	Leachate Collection System, granular material.	Minimize clogging and maintain less than one foot of leachate on the underlying geomembrane.	Provide granular material which has a hydraulic conductivity $\geq$ 0.01 cm/s	Engineering analysis. Demonstrate selected granular material will provide adequate drainage under surcharge.	To be selected following analysis.
	Leak Detection System (LDS)	Meet the above performance standards for the LCS.	6- CCR -1007-3 264.300, Subpart N - Landfill and applicable guidance presented above for the LCS.	Engineering analysis.	To be selected following analysis.
	Leachate Collection System, piping	Provide, to the extent necessary, drainage of the granular or synthetic drainage media of the LCS to maintain less than one foot of leachate on the immediate underlying layer.	Prevent clogging through design and maintenance.	Engineering analysis of flow velocities.	To be selected following analysis.
	LCS/LDS, sump	Allow for the removal and measurement of leachate.		Engineering analysis of flow velocities, accessibility, and constructiblity.	To be selected following analysis.
6. Optional Cover Designs	Operational Cover	Provide a water-tight structure which is structurally sound during the operational period of the RWSF. Designed to accommodate dust suppression for operations.	Past proven technologies. May be identical to storage cover design in appropriate.	Engineering analysis.	To be selected following analysis.
	Earthen Cover Option	Accommodate settlement to maintain cover integrity and promote gravity drainage to the perimeter. Maintain slopes and vegetative cover.	EPA cover guidelines and proven technologies.	Specific details and drawings will be identified under Title II design	Criteria to be selected during Title II Design.
	Metal Roof Option	Sized and designed to minimize deflection and provide watertight structure and be structurally stable.	Steel Joist Institute (SJI) , AISC, and UBC. Standard practice has proven technology	Specific details and drawings will be identified under Title II design.	Criteria to be selected during Title II Design

ATTACHMENT I - Preliminary Design Parameters for CAMU for Bulk Storage

Design Item	Component	Performance Standard[1]	Design Guidance[3]	Design Parameter Demonstration[3]	Resultant Design Criteria[4]
	Twin-Tee Precast Concrete Option	Sized and designed for loads encountered to minimize *deflection* , be structurally stable and become a watertight structure.	ACI standards and past standard practice has proven technology	Specific details and drawings will be identified under Title II design	To be selected following analysis during Title II Design.
7. Groundwater Cutoff Trenches	General	Design must maintain separation between groundwater and RWSF liner system.		Engineering analysis.	To be selected following analysis.
8. Run-On/ Run-Off	General	Provide run-on control system capable of preventing flow onto the active portion of the RWSF during peak discharge from at least a 100-year storm. Provide a runoff management system to collect and control at least the water volume resulting from a 24-hour, 100-year storm,	6 - CCR -1007-3 264.300, Subpart N Landfill requirements. Denver Urban Storm Drainage Criteria Manual , and RFETS Standards SC-109.	Engineering drawings, profiles, and calculations to size system including estimates of peak flow rates, erosion potential, management of water systems, separation of run-on and runoff, provisions for retention of runoff.	To be selected following analysis.

ACI - American Concrete Institute
AISC - American Institute of Steel Construction
ASCE - American Society Civil Engineering
ASTM - American Society of Testing Materials
CCL - Compacted Clay Liner
RWSF - Remediation Waste Storage Facility
UBC - Uniform Building Code

1. Performance Standard: An objective for design that is based on a regulatory requirement, regulatory guidance, and/or standard practice.
2. Design Guidance: Standard engineering practice reference manuals and design elements that have been identified in regulatory guidance or have been demonstrated by past practice to meet the performance standards.
3. Design Parameter Demonstration: Analysis required to demonstrate that the design criteria will provide conformance with the design guidance and the performance standard.
4. Resultant Design Criteria: Specific elements of design that have been shown by supporting analytical demonstration to meet related performance standard.

ATTACHMENT II

GEOTECHNICAL DATA

Consolidation Test Data - Borehole 54594

Depth (ft)	Compression Index	Recompression Index	Initial Void Ratio	Unit Weight (lb/ft^2)	Preconsolidation Pressure (psf)
7.0-7.8 #1	0.1192 min. 0.7355 max.	0.0111	0.6698	113.0	NA
7.0-7.8 #2	0.1226	0.0122	0.5274	124.6	3550
8.0-8.8 #1	0.1615	0.0609	0.6281	130.6	2400
8.0-8.8 #2	0.1568	0.0514	0.6044	127.9	5000

Refer to OU4 Solar Evaporation Pond IM/IRA Project, Volume 2, 90% Review (EG&G, 1995a)

Standard Penetration Test - Boreholes TH 7 and 8[1]

Borehole	Depth (ft)	Number of Blows[2]	Drive Depth (in)
TH-7C	5	41	12
TH-7D	5	50	11
TH-7D	15	50	11
TH-8	5	35	12
TH-8	10	50	12
TH-8	15	50	12

2 - 140 pound hammer - 30" drop

1 - Refer to RFETS soil report #A7, R. V. Lord & Assoc., September 13, 1972, Proposed Sewer Line.

Laboratory Hydraulic Conductivity Results[1]

Borehole	Depth (ft)	Lithology	USCS	K_{sat} (cm/sec) Falling Head
41793	4.1-4.8	Alluvium	SC	1.2×10^{-5}
41793	7.0-7.7	Alluvium	GM	5.7×10^{-6}
43193	4.0-4.7	Alluvium	GM	2.0×10^{-3}
44093	4.0-4.5	Alluvium	CH	1.2×10^{-6}
44093	13.1-13.8	Claystone	-	1.3×10^{-7}

1 - Refer to OU4 IM/IRA Decision Document

Field Hydraulic Conductivity Results[1]

Borehole	Depth	USCS	Lithology	Hydraulic Conductivity K (cm/sec)	Test Method
41793	12.0 in.	GP	Alluvium	1.57×10^{-5}	Guelph
44093	14.5 in.	SM	Alluvium	6.7×10^{-5}	Guelph
44093	16.99 ft.	Bedrock	Claystone	3.2×10^{-10}	BAT

1 - Refer to OU4 IM/IRA Decision Document

ATTACHMENT III

PRELIMINARY LIST OF APPLICABLE CODES, STANDARDS, AND GUIDELINES

The most current revision or controlled copies of the following codes, standards and guidelines apply to the design of this project.

General

1. **DOE Order 6430.1A, United States Department of Energy, General Design Criteria.**

2. **DOE Order 5820.2A, Radioactive Waste Management, Chapter III, Management of Low Level Waste.**

3. **DOE Order 4700.1A, Department of Energy Project Management System.**

4. **RFETS Conduct of Engineering Manuals, Volumes 1, 2, 3, 4 and 5.**

5. **RFETS Configuration Change Control Program Manual.**

6. **RFETS Standards, Volumes I, II, III, IV, V and VI.**

7. **RFETS Health and Safety Practices Manual.**

8. **RFETS Radiological Control Manual**

9. **Department of Energy (DOE) Environmental Protection, Safety and Health Protection Standards, DOE Order 5480.4.**

10. **ASTM Standards as applicable**

Civil

1. **Manual on Foundation Investigations, American Association of State Highway and Transportation Officials.**

2. **Subsurface Investigation for Design and Construction of Foundations of Buildings, American Society of Civil Engineers.**

3. **American Society of Civil Engineers - Manual No. 37, "Design and Construction of Sanitary and Storm Sewers."**

4. **American Water Works Association - "Standards."**

5. **American Association of State Highway and Transportation Officials - "Geometrics Design and Highway Standards."**

6. Colorado State Highway Department - "Standard Specifications for Road and Bridge Construction."

7. Jefferson County, Storm Drainage Design and Technical Criteria.

8. Colorado Division of Water Resources, Revised and Amended Rules and Regulations for Water Well Construction and Pump Installation, 1988.

9. American Association of State Highway and Transportation Officials - "Policy on Design of Urban Highway and Arterial Streets."

10. Asphalt Institute - "Asphalt Paving Manual," "Thickness Design Manual," "Soils Manual for Design of Asphalt Pavement Structures."

11. RFETS Standard SC-0102 - Security Fencing

12. RFETS Standard SC-0109 - Storm Sewer Design Criteria

13. RFETS Standard SF-0100, Fire Protection

14. Denver Regional Council of Governments, Urban Storm Drainage Criteria Manual.

<u>Environmental</u>

1. Colorado Department of Public Health and Environment, Colorado Hazardous Waste Regulations, Code of Colorado Regulations, 6 CCR 1007-3

2. Colorado Department of Public Health and Environment, Siting of Hazardous Waste Disposal Facilities, Code of Colorado Regulations, 6 CCR 1007-2, Part 2.

3. Colorado Department of Public Health and Environment - Air Pollution Control Division, Colorado Air Pollution Control Regulations, Code of Colorado Regulations, Title 5, Chapter 1001, Regulations #1, 2, 3, 8).

4. Colorado Department of Public Health and Environment - Air Pollution Control Division, Colorado Ambient Air Quality Standards and New Source Performance Standards (Colorado Code of Regulations, Volume 5, Parts 14, 8).

5. Colorado Department of Public Health and Environment - Water Quality Control Division, Colorado Water Quality Control Regulations and Discharge Permit System Regulations, (Code of Colorado Regulations, Title 5, Chapter 1002, Articles 2, 3, 6).

6. Colorado Department of Public Health and Environment - Water Quality Control Division, Colorado Water Quality Standards, Groundwater Standards (Code of Colorado Regulations, Title 5, Chapter 1002, Article 8).

7. U.S. Environmental Protection Agency/Colorado Department of Health - Water Quality Control Division, Stormwater Discharge Regulations (40 CFR 122.26).

8. U.S. Department of Energy, National Environmental Policy Act Compliance, National Environmental Policy Act, 40 CFR Parts 1500 - 1508 (CEQ regulations to implement NEPA); DOE 5440.1C; 10 CFR 1021 (incorporates requirements for compliance with Endangered Species Act, Fish and Wildlife Coordination Act, National Historic Preservation Act).

9. Colorado Department of Public Health and Environment, Radiation Control Requirements, Nuclear Regulatory Commission, Code of Colorado Regulations, 6CCR 1007-1, Part 14, Licensing Requirements for Land Disposal of Low Level Radioactive Waste.

10. RFETS Standard FO.5 - Handling of Purge and Development Water.

11. RFETS Standard FO.7 - Handling of Decontamination Water and Wash Water.

12. RFETS Standard FO.8 - Handling of Drilling Fluids and Cuttings.

13. RFETS Standard FO.13 - Containerizing, Preserving, Handling, and Shipping of Soil and Water Samples.

14. RFETS Standard GW.1 - Water Level Measurements in Wells and Piezometers.

15. RFETS Standard GW.2 - Well Development.

16. RFETS Standard GW.5 - Field Measurement of Groundwater Field Parameters.

17. RFETS Standard GW.6 - Groundwater Sampling.

18. RFETS Standard GT.1 - Logging Alluvial and Bedrock Material.

19. RFETS Standard GT.2 - Drilling and Sampling Using Hollow Stem Auger Techniques.

20. RFETS Standard GT.6 - Monitoring Wells and Piezometer Installation.

Architectural

1. NFPA-101 Life Safety Code, and NFPA Life Safety Code Handbook.

2. RFETS Standard SC-0100, Hollow Metal Doors and Frame

3. RFETS Standard, Builders Hardware

4. RFETS Standard, SC-0104, Standard for Glass and Glazing

Structural

1. AISI Specification for the Design of Cold-Formed Steel Structural Members.

2. AISC Steel Construction Manual, American Institute of Steel Construction,

3. ASCE 7, Minimum Design Loads for Buildings and Other Structures.

4. AWS D1.1, Structural Welding Code-Steel, American Welding Society.

5. RFETS Standard SC-0106, Equipment Seismic Qualification

6. SEAC, "1984 Structural Survey of Colorado Building Department and 1971 Snow Load Design Data for Colorado." (1984 Reprint), Structural Engineers Association of Colorado, December 1984.

7. DOE-STD-1021, "Natural Phenomena Hazards Performance Categorization Criteria for Structures, Systems, and Components"

8. DOE-STD-1020, "Natural Phenomena Hazards Design and Evaluation Criteria for Department of Energy Facilities".

9. ACI 318, Building Code Requirements for Reinforced Concrete, American Concrete Institute

10. Uniform Building Code (UBC), International Conference of Building Officials (ICBO).

Mechanical/Process

1. Backflow Preventor Standards, ENG-ST-73, 1/10/79; ENG-ST-72, 12/12/78; and ENG-ST-75, 12/20/78.

2. Uniform Plumbing Code, published by the International Association of Plumbing and Mechanical Officials (IAPMO).

3. Uniform Mechanical Code, published by the International Association of Plumbing and Mechanical Officials (IAPMO) and the International Conference of Building Officials (ICBO).

4. Energy Conservation in New Buildings, ASHRAE Standard 90, administered by the American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.

5. Ventilation for Acceptable Indoor Air Quality, ASHRAE Standard 62, administered by the American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.

6. RFETS Standard SMU-0100, Safety Showers

7. RFETS Standard SMU-0101, Safety Eye/Face Washes

8. RFETS Standard SMU-0302, Ventilation Design

9. RFETS Standard SMU-0303, Heating, Ventilation and Air Conditioning Standard

10. RFETS Standard SMU-0304, Standard for Fans

11. Climate Data for Air Conditioning Design, Rocky Mountain Chapter Region

12. RFETS Standard SX-0128, Cleaning and Cleanliness Control

13. RFETS Standard SM-0136, Tanks Containing Regulated Substances

14. RFETS Standard SP-0136 - P&ID - Legends and Symbols

15. RFETS Standard SP-0211 - Fabrication of Piping Systems

16. RFETS Standard SP-0220, Piping Materials Specifications

17. RFETS Standard SP-0301, Pipe Systems Testing Procedure

18. RFETS Standard SP-0401 - General Pipe Insulation

<u>Electrical</u>

1. MIL-HDBK- 1004/4, Electric Utilization Systems

2. NFPA 780, Lightning Protection Code

3. NFPA 70, National Electric Code (NEC)

4. NFPA 75, Protection of Electronic Computers/Data Processing

5. NFPA 101, Life Safety Code.

6. NFPA 110, Emergency and Standby Power Systems.

7. ANSI/IEEE 141, IEEE Recommended Practice for Electric Power Distribution for Industrial Plants.

8. ANSI/IEEE 142, IEEE Recommended Practice for Grounding of Industrial and Commercial Power Systems.

9. ANSI/IEEE 241, IEEE Recommended Practice for Electric Power Systems in Commercial Buildings.

10. ANSI/IEEE 242, IEEE Recommended Practice for Grounding of Industrial and Commercial

Power Systems.

11. ANSI/IEEE 446, IEEE Recommended Practice for Emergency and Standby Power Systems for Industrial and Commercial Applications.

12. ANSI/IEEE 493, IEEE Recommended Practice for Design of Reliable Industrial and Commercial Power Systems

13. ASHRAE 90A, Energy Conservation in New Building Design

14. RFETS Standard SAM-0103, Instrumentation & Alarms

15. RFETS Standard SAM-0104, Level Sensors

16. RFETS Standard SC-0107, Sealing Building Penetrations & Electrical Conduit

17. RFETS Standard SE-0103, Standard for Electrical Wiring

18. RFETS Standard SE-0105, Motor Control 3 Wire P/B Standards

19. RFETS Standard SE-0107, Quality Control of Molded Case Breakers

20. RFETS Standard SE-0112, Building Electrical Raceway Systems

21. RFETS Standard SE-0205, Emergency Exit Signs

22. RFETS Standard SE-0301, Emergency Lighting Equipment

23. RFETS Standard SE-0401, Audible Warning Devices for Life Safety/Disaster Warning System

24. RFETS Standard SE-0550, Telephone Conduit and Equipment Installation,

25. RFETS Standard SE-0701, Alarm System Cables

26. RFETS Standard SE-0901, Security Alarm Single Personnel Door

27. RFETS Standard SF-0100, Fire Protection Standard

28. RFETS Standard SX-0164, Plant System and Component Identification System and Labelling

29. UL 96, Lightning Protection Components.

30. UL 96A, Lightning Protection Installation Practices.

The specifications and requirements of this attachment are RFETS typical standards and are intended to be examples only. These standards and requirements are provided to give enough information to designate the CAMU. Modifications might be necessary to address issues as part of the more detailed Title II Design. Only key specifications have been included. During development of the Design the following specifications would likely be used. These specifications are RFETS standards.

SPEC #	SPEC TITLE
02621	**Compacted Clay Liner**
02623	**Leachate Collection and Leak Detection Gravel**
02670	**Geomembrane Liner System**
02710	**Leachate Collection and Leak Detection Geotextiles, Geonets and Geopipes**
03300	**Cast-in-Place Concrete**

Additional possible specifications not included in this attachment:

SPEC #	SPEC TITLE
	DIVISION 1 - GENERAL REQUIREMENTS
01100	**Special Contract Requirements**
01300	**Submittals**
01400	**Quality Assurance/Quality Control**
01500	**Temporary Facilities, Controls and Special Project Requirements**
01610	**Material Handling and Waste Disposal**
01700	**Subcontractor Safety**
	DIVISION 2 - SITEWORK
02070	**Installing, Plugging, and Abandoning Monitoring Wells**
02200	**Earthwork**
02210	**Test Fill**
02231	**Aggregate Base Course**
02680	**Geosynthetic Clay Liner**
02687	**Site Gas Lines**
02690	**Geosynthetic Reinforced Earth Slope**
02722	**Site Storm Sewer Systems**
02781	**Site Grounding**
02800	**Signage**
02830	**Chain-Link Fencing**
02900	**Topsoil and Revegetation**
02930	**Erosion Control Measures**
02936	**Rip Rap**
	DIVISION 3 - CONCRETE
03100	**Concrete Formwork**
03200	**Concrete Reinforcement**
03346	**Concrete Floor Finishing**
03370	**Concrete Curing**
03410	**Structural Precast Concrete**

DIVISION 4 - MASONRY

04100 Mortar and Masonry Grout

04310 Single Wythe Masonry System

DIVISION 5 - METALS

05500 Metal Fabrications

05520 Handrails and Railings

05531 Gratings and Floor Plates

DIVISION 6 - WOOD AND PLASTICS

06200 Finish Carpentry

DIVISION 7 - THERMAL AND MOISTURE PROTECTION

07181 Water Repellent Coating

07212 Rigid Insulation

07900 Joint Sealers

DIVISION 8 - DOORS AND WINDOWS

08111 Standard Steel Doors

08112 Standard Steel Frames

08331 Overhead Coiling Doors

08360 Sectional Overhead Doors

08520 Aluminum Windows

08710 Door Hardware

08800 Glazing

DIVISION 9 - FINISHES

09260 Gypsum Board Systems

09311 Ceramic Tile Floor Finish

09312 Ceramic Tile Wall Finish

09511 Suspended Acoustical Ceilings

09650 Resilient Tile Flooring

09705 Epoxy Seamless Liner and Floor Finish

09900 Painting

DIVISION 10 - SPECIALTIES

10165 Plastic Laminate Toilet Compartments

10191 Cubicle Curtains

10440 Interior and Exterior Signage/Graphics

10508 Metal Wardrobe Lockers

10522 Fire Extinguishers and Accessories

10800 Toilet and Bath Accessories

DIVISION 11 - EQUIPMENT

11140 Miscellaneous Equipment

11144 Vehicle Wash Equipment

11500 Emergency Eyewash Station

DIVISION 12 - FURNISHINGS

12512 Horizontal Louver Blinds

DIVISION 13 - SPECIAL CONSTRUCTION

13080 Seismic and Vibration Isolation Requirements
13121 Pre-Engineered Buildings (B283)
13200 Leachate Storage Tanks
13205 Equipment Painting
13210 Leachate System Pumps
13215 Piping
13216 Piping Insulation
13410 Instrumentation
13420 Control Panels

DIVISION 15 - MECHANICAL

15050 Basic Mechanical Materials and Methods
15100 Valves
15135 Meters and Gages
15145 Hangers and Supports
15170 Motors
15240 Vibration Isolation
15250 Mechanical Insulation
15410 Plumbing Piping
15430 Plumbing Specialties
15440 Plumbing Fixtures
15451 Diaphragm Pumps
15452 Vertical Sump Pumps
15453 Horizontal End Suction Pumps
15454 Regenerative Turbine Pumps
15455 Liquid Storage Tanks
15460 Water Heaters
15488 Propane Gas Piping Systems
15575 Metal Vents
15620 Fuel Fired Heaters
15782 Packaged Air Terminal Units
15852 Axial Fans
15870 Power Ventilators
15891 Metal Ductwork
15910 Duct Accessories
15932 Air Outlets and Inlets
15971 Electric Control Systems
15985 Sequence of Operation

15990 Testing, Adjusting and Balancing

DIVISION 16 - ELECTRICAL

16010 Electrical Basic Requirements
16050 Basic Electrical Methods and Materials
16111 Conduit
16118 Ductbank
16121 Medium Voltage Cable
16123 Building Wire and Cable
16130 Boxes
16140 Wiring Devices
16160 Cabinets and Enclosures
16170 Grounding and Bonding
16190 Supporting Devices
16195 Electrical Identification
16311 Unit Substation
16365 Medium Voltage Switch and Fuses
16370 Overhead Power Distribution
16426 Distribution Switchboards
16441 Enclosed Switches
16461 Dry-Type Transformers
16470 Panelboards
16481 Enclosed Motor Controllers
16482 Motor Control Center
16496 Enclosed Isolation Bypass, Automatic Transfer Switch
16510 Interior Luminaries
16530 Site Lighting
16620 Packaged Engine Generator Systems
16641 Cathodic Protection
16670 Lightning Protection System
16721 Fire Alarm Systems
16741 Telephone System, Pathways and Wiring
16742 Telephone System, Outside Plant
16770 Life Safety and Disaster Warning System
16855 Heat Tracing Cables
16902 Electric Controls and Relays

SECTION 02621

COMPACTED CLAY LINER

PART 1 - GENERAL

1.1 SECTION INCLUDES

1.1.1 Furnishing, mixing, conditioning, placing, compacting, and testing clay liner material in the cell .

1.2 RELATED SECTIONS

1.2.1	Section 01300	Submittals
1.2.2	Section 01400	Quality Control/Quality Assurance
1.2.3	Section 02200	Earthwork
1.2.4	Section 02210	Test Fill
1.2.5	Section 02670	Geomembrane Lining System
1.2.6	Section 02680	Geosynthetic Clay Liner

1.3 REFERENCES

The latest issues of the following publications form a part of this Specification:

1.3.1 All references listed herein are incorporated as part of this Specification.

1.3.2 Publications listed below form part of this Specification to the extent referenced.

1.3.3 American Society for Testing and Materials (ASTM)

1.3.3.1	ASTM D420	Practice for Investigation and Sampling Clay and Rock for Engineering Purposes
1.3.3.2	ASTM D422	Method for Particle-Size Analysis of Soils
1.3.3.3	ASTM D698	Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft- lbf/ft^3) (2,700 kN-m/m^3).
1.3.3.4	ASTM D1140	Test Method for Amount of Material in Soils Finer Than the 200 Sieve
1.3.3.5	ASTM D1556	Test Method for Density of Soil In Place by the Sand-Cone Method
1.3.3.6	ASTM D1557	Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft^3) (2,700 kN-m/m^3).
1.3.3.7	ASTM D2167	Test Method for Density and Unit Weight of Soil In Place by the Rubber Balloon Method
1.3.3.8	ASTM D2216	Method for Laboratory Determination of Water (Moisture) Content of Soil, Rock, and Soil-Aggregate Mixtures
1.3.3.9	ASTM D2487	Test Method for Classification of Soils for Engineering Purposes
1.3.3.10	ASTM D2922	Test Methods for Density of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth)
1.3.3.11	ASTM D2937	Test Method for Density of Soil In Place by Drive Cylinder Method
1.3.3.12	ASTM D3017	Test Method for Moisture Content of Soil and Soil-Aggregate In Place by Nuclear Methods (Shallow Depth)
1.3.3.13	ASTM D4318	Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils
1.3.3.14	ASTM D4643	Test Method for Determination of Water (Moisture) Content of Soil by Microwave Oven Method
1.3.3.15	ASTM D5084	Test Method for Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Parameter

1.3.4 "Quality Assurance and Quality Control for Waste Containment Facilities", Technical Guidance Document EPA/600/R-93/182, September, 1993.

1.4 DEFINITIONS

1.4.1 Acceptable Zone - A zone of moisture content and dry density which yields a hydraulic conductivity not exceeding 1×10^{-7} centimeters/second. The acceptable zone is developed based on Reference C, paragraph 1.3 of this section.

1.5 SUBMITTALS

1.5.1 Submit under provisions of Section 01300 - Submittals.

1.5.2 Pre-Construction Submittals. Within 14 calendar days of receipt of the Notice to Proceed, submit a construction plan that includes:

1.5.2.1 Proposed borrow source(s) and proposed method(s) of sampling borrow source for acceptance.
1.5.2.2 Proposed clay processing, placement, compaction, and moisture control equipment and procedures, including:

1.5.2.2.1 Equipment catalog data including weight, dimensions, and operating data;
1.5.2.2.2 Proposed clay placement method specifying proposed minimum width of horizontal benches.

1.5.2.3 Proposed Work Schedule including;

1.5.2.3.1 Drawings of the plan view of the cell indicating clay placement sequence, including haul routes;
1.5.2.3.2 Work plan indicating coordination of clay placement in the cell with the installation of the geosythethics.

1.5.2.4 Proposed method of protecting Work.
1.5.2.5 Proposed QC firm and their qualifications.
1.5.2.6 Proposed testing laboratory, including:

1.5.2.6.1 Description of laboratory equipment
1.5.2.6.2 Experience level of sampling personnel
1.5.2.6.3 Experience level of laboratory personnel

1.5.2.7 Proposed surveyor.
1.5.2.8 Proposed method of controlling stormwater runoff during construction.
1.5.2.9 Proposed source of water.

1.5.3 Borrow Source Quality Control Submittals

1.5.3.1 At least 30 calendar days prior to construction of the Test Fill, submit:

1.5.3.1.1 Survey records - Submit survey records and quantity calculations to verify that the quantity of clay available for this project from the proposed borrow source is equal to at least twice the estimated quantity required. The limits of the survey for the borrow source shall be the actual boundaries from which the clay for this project is to excavated, including the additional area to represent twice the volume. The borrow source area shall be defined as the specific area at the borrow source from which clay for this project will be excavated.
1.5.3.1.2 100 pound soil sample from each proposed clay borrow source.
1.5.3.1.3 Laboratory test results on samples from each proposed borrow source including:

1.5.3.1.3.1 Gradation ASTM D422, D1140
1.5.3.1.3.2 Atterberg Limits ASTM D4318
1.5.3.1.3.3 Natural Moisture Content ASTM D2216
1.5.3.1.3.4 Moisture-Density Relationship ASTM D1557
1.5.3.1.3.5 Moisture-Density Relationship ASTM D698
1.5.3.1.3.6 Moisture-Density Relationship - Reduced Standard Proctor (ASTM D698 - Refer to paragraph 2.2.4.b)
1.5.3.1.3.7 Laboratory Hydraulic Conductivity ASTM D5084

Refer to paragraph 2.2.A for testing frequencies.

1.5.3.1.4 The Acceptable Zone of moisture and density, determined in accordance to Reference C, paragraph 1.3.C of this section.

1.5.4 Source Quality Control Construction Testing Submittals

1.5.4.1 Within two working days of completion of the required tests, submit test results for the following laboratory tests:

1.5.4.1.1 Gradation ASTM D422, D1140
1.5.4.1.2 Atterberg Limits ASTM D4318
1.5.4.1.3 Natural Moisture Content ASTM D216
1.5.4.1.4 Moisture-Density Relationship ASTM D698
1.5.4.1.5 Laboratory Hydraulic Conductivity ASTM D5084

Refer to paragraph 2.2.B for testing frequencies.

1.5.5 Field Quality Control Test Submittals

1.5.5.1 Submit in-place moisture content and in-place density test results the next working day after test completion.
1.5.5.2 Submit laboratory test results the next working day after completion of test.
1.5.5.3 Submit topographic scalable survey drawings and survey data of subgrade and the top surface of the clay layer within 2 working days after completion of survey.
1.5.5.4 Submit daily clay placement rates for the cell within one working day of clay placement.

1.6 QUALITY CONTROL QUALIFICATIONS

1.6.1 Quality control firm specializing in QC testing and observations described in this Section, with at least three years of documented experience performing QC work on similar types of projects.

1.6.2 Testing laboratory, independent of Construction Subcontractor, capable of producing certifiable test results.

1.6.3 Professional land surveyor registered in the State of Colorado.

1.7 DELIVERING AND STOCKPILING

1.7.1 Delivering

1.7.1.1 Ensure that clay borrow material delivered to site meets the material requirements specified herein.

1.7.2 Stockpiling

1.7.2.1 Stockpile clay liner material in area shown on the drawings or as directed by the Contractor. Do not stockpile on completed Work.

1.8 PROJECT CONDITIONS

1.8.1 Environmental Requirements

1.8.1.1 Do not place clay liner under the following conditions:

1.8.1.1.1 Ambient air temperature is below 32°F.
1.8.1.1.2 Standing water on Work surfaces or clay moisture contents are above specified range.

1.8.1.2 Control surface water run-off and run-on. Install clay liner in a manner that promotes run-off of compacted surfaces and prevents run-on and ponding. Do not allow standing water to accumulate on top of clay lift surfaces.

1.9 SCHEDULING AND SEQUENCING

1.9.1 Coordination

1.9.1.1 Coordinate with the GCL Installer for final subgrade preparation prior to the placement of GCL.

PART 2 - PRODUCTS

2.1 MATERIALS

2.1.1 Clay Liner

2.1.1.1 A natural material, free of debris, roots, organic matter, and frozen material. Clay liner shall be homogeneous and have a uniform moisture content.

2.1.1.2 Gradation:

2.1.1.2.1 100 percent by weight passing the 1 inch sieve
2.1.1.2.2 At least 60 percent by weight passing the U.S. No. 4 sieve
2.1.1.2.3 At least 50 percent by weight passing the U.S. No. 200 sieve

2.1.1.3 Atterberg limits:

2.1.1.3.1 Plastic limit, greater than 10
2.1.1.3.2 Liquid limit, greater than 25
2.1.1.3.3 Plasticity index, greater than 10

2.1.1.4 In place hydraulic conductivity: Not exceeding 1.0×10^{-7} centimeters/second.

2.1.1.5 Free of hazardous chemicals or other contaminants.

2.1.2 Water for Moisture Conditioning Clay Liner Material

2.1.2.1 Potable water from an approved source.

2.2 SOURCE QUALITY CONTROL

2.2.1 Borrow Source Acceptance

2.2.1.1 Do not deliver borrow soil to site until specified borrow source sampling and testing is completed and borrow source is approved by the Contractor. Perform borrow source sampling and testing as specified in subparagraphs 2.2.1.2 through 2.2.1.5, for every 50,000 cubic yards or less of borrow soil for each borrow source.

2.2.1.2 Submit sampling plan within 7 calendar days in advance of sampling. Do not sample until plan is approved.

2.2.1.3 Sampling program shall meet the following requirements:

2.2.1.3.1 Samples shall be collected by an approved QC Inspection firm in the presence of the CQAO.
2.2.1.3.2 A minimum of 10 sampling locations randomly selected from a predetermined grid.
2.2.1.3.3 Samples for natural moisture content shall be sealed at the time of sampling.
2.2.1.3.4 A minimum of 50 pounds of soil or a weight sufficient to complete the required tests shall be collected at each sampling location. Air dry samples and thoroughly mix equal weights for moisture-density and hydraulic conductivity tests.

2.2.1.4 Perform the following laboratory tests:

2.2.1.4.1 Atterberg limits in accordance with ASTM D4318, natural moisture contents in accordance with ASTM D2216, and particle size analysis in accordance with ASTM D422, using the following test frequencies:

2.2.1.4.1.1 One test each for each borrow source sample (10 tests per borrow source)
2.2.1.4.1.2 3 tests each on the prepared (mixed and split) bulk samples used for moisture-density and hydraulic conductivity tests

2.2.1.4.2 One (1) Reduced Standard Proctor test (ASTM D698 using 15 blows per lift) using a minimum of five compaction points on homogenized sample with moisture contents in the range of 2 percent dry of optimum to 6 percent wet of optimum.
2.2.1.4.3 One (1) Standard Proctor test (ASTM D698) using a minimum of five compaction points on homogenized sample with moisture contents in the range of 2 percent dry of optimum to 6 percent wet of optimum.
2.2.1.4.4 One (1) Modified Proctor test (ASTM D1557) using five compaction points on homogenized sample

with moisture contents in the range of 2 percent dry of optimum to 6 percent wet of optimum.

2.2.1.4.5 Fifteen (15) hydraulic conductivity tests (ASTM D5084) on test specimens used to develop the compaction curves listed in subparagraphs 2.2.A.4, b through d. Perform tests using a consolidation pressure of 5 pounds per square inch. These hydraulic conductivity tests, along with the Modified, Standard and Reduced Proctor tests, will provide the data required to develop the Acceptable Zone of moisture and density. This Acceptable Zone may be modified by the CQAO based on the tests performed during test fill construction. Refer to Section 02210 - Test Fill for details of test performed during test fill construction. The Acceptable Zone shall be used by the QC Inspector for field quality control for moisture content and density.

2.2.1.5 Furnish test results to CQAO for evaluation and approval of borrow source.

2.2.2 Source Quality Control Tests Performed During Construction

2.2.2.1 Approved, QC Inspection firm shall perform all field quality control tests. Collect borrow soil samples in accordance with ASTM D420.

2.2.2.2 Collect clay liner samples from material delivered to the site and test samples in accordance with the following standards and frequencies:

Parameter	Standard	Frequency
Percent fines	ASTM D1140	1 every 1,000 cy
Percent gravel	ASTM D422	1 every 1,000 cy
Atterberg limits	ASTM D4318	1 every 3,000 cy
Natural moisture content	ASTM D2216	1 every 1,000 cy
Moisture-density relationship	ASTM D698	1 every 3,000 cy
Hydraulic conductivity	ASTM D5084	1 every 5,000 cy

Hydraulic conductivity tests shall be performed on samples prepared at moisture contents and densities which define the lower bound of the Acceptable Zone and at a consolidation pressure of 5 pounds per square inch.

2.2.2.3 If test results or visual observation by CQAO indicates a change in borrow soil, CQAO will request additional sampling and testing to ensure that soil characteristics have not changed. Perform additional sampling and testing requested by the CQAO at no additional cost to Contractor.

PART 3 - EXECUTION

3.1 PREPARATION

3.1.1 Subgrade Preparation

3.1.1.1 Prepare subgrade to be covered by clay liner in accordance with Section 02200 - Earthwork.

3.1.1.2 Perform topographic survey of subgrade in accordance with Section 02200 - Earthwork, prior to placement of clay liner.

3.1.1.3 Do not place clay liner before Contractor approves subgrade.

3.1.2 Borrow Source Area Operations

3.1.2.1 Excavate borrow soil in a manner to avoid inclusion of organic matter, sand and gravel, or other deleterious materials. Process clay to remove roots, sticks, rocks, and debris by screening or other methods.

3.1.2.2 Thoroughly mix borrow soil to produce homogeneous material using rotovator, pulvermixer, disc, screens, or other methods. Remove or pulverize clods larger than 2 inches.

3.1.2.3 Adjust moisture content to within specified range. Process borrow soil to produce uniform moisture content.

3.2 PLACEMENT

3.2.1 General

3.2.1.1 Place clay liner material to the lines and grades shown on drawings.

3.2.1.2 Scarify upper 1 inch of previously placed lift of clay liner using a scarifier, disc, harrow, or other approved method and maintain moisture content within specified limits to provide a satisfactory bond between lifts.

3.2.1.3 If previous lift becomes cracked or softened excessively because of moisture changes, scarify full depth of lift and recompact as specified before placing overlying lift.

3.2.1.4 Place clay liner in uniform lift thicknesses such that the loose lift thickness does not exceed 8 inches and the compacted lift thickness does not exceed 6 inches.

3.2.1.5 For sloped surfaces steeper than 2.5 horizontal to 1 vertical (2.5:1), bench slope in widths sufficient to allow the compaction equipment to operate in a horizontal orientation. On slopes between 10:1 and 2.5:1, benches shall be provided if the equipment is operated across the slope rather than up and down the slope.

3.2.1.6 Condition loose lifts prior to compaction using a rotovator, pulvermixer, rototiller, disc, or other approved method. Pulverize or remove lumps and clods to less than 1/2 inch.

3.2.2 Moisture Control

3.2.2.1 Control moisture content during placement to prevent excessive wetting or drying. Implement moisture controls including but not limited to intermittent spraying, temporary covering with plastic, temporarily covering with loose moist soil, or sealing.

3.2.2.2 Maintain moisture content in the Acceptable Zone. The Acceptable Zone shall be determined prior to construction of the test fill. Refer to paragraph 1.5.B and 2.2.A.4.e of this section for details on the development of the Acceptable Zone.

3.2.2.3 If field quality control tests indicate that moisture content is too low, apply water by even sprinkling; thoroughly mix to uniform moisture content using a rotovator, pulvermixer, rototiller, disc, or other approved method; and recompact.

3.2.2.4 If field quality control tests indicate that moisture content is to high, aerate lift by blading, discing, harrowing, or other approved method; or remove and replace the lift; or thoroughly mix in dry clay using rotovator, pulvermixer, rototiller, disc, or other approved method.

3.2.3 *Compaction*

3.2.3.1 Compact to dry density within the Acceptable Zone but at least 95% of the maximum dry density determined by ASTM D698.

3.2.3.2 *Compaction equipment shall be the same as that used to construct the test fill.* See 0220 Section 2.2.1.

3.2.4 Top Surface of Final Lift

3.2.4.1 *Compact top surface of final lift of clay liner using a smooth drum roller. Compact until surface is free of roller* marks, holes, abrupt changes in grade, depressions more than 1/2 inch deep, and protrusions more than 1/4 inch high.

3.2.4.2 Complete topographic survey of top surface of final clay liner lift.

3.2.5 Tolerances

3.2.5.1 Tolerances for the thickness of the clay liner shall be as shown on the drawings.

3.3 FIELD QUALITY CONTROL

3.3.1 Testing

3.3.1.1 Approved, independent QC testing laboratory shall perform all field quality control tests.

3.3.1.2 Randomly select sample locations using predetermined grid with approximately 10 times more grid spaces than sampling locations. Furnish CQAO proposed method for approval.

3.3.1.3 Test compacted clay layer in accordance with the following standards and frequencies:

Parameter	Standard	Frequency
Moisture Content	ASTM D3017, or ASTM D4643	-one per 300 cy -one per 10,000 sf per lift -two per 8 hour shift

Parameter	Standard	Frequency
In-Place Density	ASTM D2922, or ASTM D2937	-one per 300 cy -one per 10,000 sf per lift -two per 8 hour shift
One Point Proctor	ASTM D698	-one per day for each day of placement -one per material type
Sand Cone or Rubber Balloon	ASTM D1556 ASTM D2167	-one per 3,000 cy during first 2 weeks of clay placement -one per 6,000 cy after first 2 weeks of clay placement -one per 50,000 sf per lift -one per 8 hour shift
Oven Dried Moisture Content	ASTM D2216	-one per 1,500 cy -one per 50,000 sf per lift -one per 8 hour shift

3.3.1.4 The testing frequency which results in the greatest number of tests shall be used to determine the minimum test frequency.

3.3.1.5 Criteria for acceptance of in-place moisture content and dry density shall be based upon the Acceptable Zone and the required percent compaction.

3.3.1.6 Furnish test results to CQAO by the next working day.

3.3.1.7 If the CQAO suspects the accuracy of the QC nuclear density gauge based on the review of QA test comparisons, the Construction Subcontractor shall be responsible for proposing corrective actions to be taken to resolve discrepancies. The CQAO must approve the proposed corrective action prior to performing any additional tests with the QC nuclear density gauge.

3.3.2 Options for failed tests:

3.3.2.1 Moisture content: Re-test same area. If second test fails, remove or rework clay to depth of failing test to lateral extent defined by other tests meeting acceptance criteria.

3.3.2.2 In-place density: Recompact and re-test same area. If second test fails, remove clay to depth of failing test to lateral extent defined by other tests meeting acceptance criteria.

3.3.3 Topographic survey

3.3.3.1 Approved, registered professional land surveyor to complete survey.

3.3.3.2 Measure elevations on 50 foot grid and at grade breaks.

3.3.3.3 Survey accuracy shall be as shown on the drawings.

3.3.3.4 The survey drawings shall be of the same scale as the design drawings for the subgrade and top of the final clay liner layers for the cell. The survey drawings shall indicate spot elevations, to the nearest 0.01 feet.

3.3.3.5 Survey data shall consist of horizontal and vertical control data for all points surveyed by the Construction Subcontractor for the subgrade and top of the final clay liner layers for the cell. Horizontal and vertical control data shall be recorded to the nearest 0.01 foot.

3.3.4 Clay Liner Repairs

3.3.4.1 Repair all penetrations in the clay liner including but not limited to: nuclear density test probe holes, sand cone holes, test pit holes, sampling holes, and grade stake holes. Backfill holes with clay liner material. Place clay liner material in 2-inch lifts and tamp several times with steel rod or other approved device that compacts the backfill with no bridging. Repeat the process until the hole is filled.

3.3.4.2 Bentonite pellets or chips may be used to backfill clay penetration. Bentonite pellets or chips, if used, shall be placed in 2-inch lifts and tamped with approved devices. Repeat the process until the hole is filled. Hydrate the bentonite immediately after placement.

3.3.5 QC Inspector Observations

3.3.5.1 The QC Inspector shall observe and document the following:

3.3.5.1.1 physical properties of clay liner material during borrow source operations, moisture control activities, placement, and compaction

3.3.5.1.2 loose and compacted lift thicknesses

3.3.5.1.3 clod size
3.3.5.1.4 number of passes made by compactor for each lift
3.3.5.1.5 compactor operation and operation of other construction equipment on the surface of the clay liner or subgrade
3.3.5.1.6 condition of the surface of completed lifts

3.3.6 CQAO Evaluation of QC Tests

3.3.6.1 CQAO will evaluate quality control tests. CQAO may require re-testing if the accuracy of a QC test is in question.
3.3.6.2 CQAO may increase frequency of QC testing based on construction observations that indicate potential problems or changes in clay liner material, including but not limited to:

3.3.6.2.1 change in color of borrow soil
3.3.6.2.2 moisture content not uniform (too wet, or too dry)
3.3.6.2.3 material not mixed to produce homogeneous mixture
3.3.6.2.4 roller slip during compaction
3.3.6.2.5 clod size above specified size
3.3.6.2.6 pumping of clay liner material during compaction
3.3.6.2.7 degree of compaction is questionable
3.3.6.2.8 desiccation cracks, soft spots, or holes observed

3.4 PROTECTION

3.4.1 Protect compacted lifts from drying that may cause desiccation cracking, and from wetting that may cause softening.

3.4.2 Seal working surface at end of each day by rolling with steel drum, placing plastic cover, or other approved method.

3.4.3 Minimize time delays between lifts to reduce potential moisture control problems.

3.4.4 Do not route construction traffic over completed lifts.

END OF SECTION 02621

SECTION 02623

LEACHATE COLLECTION AND LEAK DETECTION GRAVEL

PART 1 - GENERAL

1.1 SECTION INCLUDES

1.1.1 Furnishing, placing, sampling and testing gravel in the bottom of the cell and to provide transmissive drainage layers for the leachate collection and leak detection systems.

1.2 RELATED SECTIONS

1.2.1 Section 01300 - Submittals

1.2.2 Section 01400 - Quality Assurance/Quality Control

1.2.3 Section 02710 - Leachate Collection and Leak Detection geotextile, geonets and geopipes

1.2.4 Construction Quality Control Plan (CQA Plan)

1.3 REFERENCES

The latest issues of the following publications form a part of this Specification:

1.3.1 All references listed herein are incorporated as part of this Specification.

1.3.2 ASTM C136 - Test Method for Sieve Analysis of Fine and Coarse Aggregates

1.3.3 ASTM D2434 - Test Method for Permeability of Granular Soils (Constant Head)

1.3.4 ASTM D4254 - Test Method for Minimum Index Density and Unit Weight of Soils and Calculation of Relative Density

1.3.5 ASTM D4373 - Test Method for Carbonate Content of Soils

1.4 SUBMITTALS

1.4.1 Submit in accordance with Section 01300: Submittals.

1.4.2 Preconstruction Submittals.

A Construction Plan shall be submitted and approved by the Contractor prior to the import or placement of gravel materials.

1.4.2.1 Proposed borrow source(s) and proposed method of sampling borrow source.
1.4.2.2 Proposed equipment and placement method for all gravel details including: sumps, Cell bottoms, and pipes.
1.4.2.3 Proposed method to control thickness during placement

1.4.3 Source Quality Control Submittals.

Prior to delivery of gravel to the site, submit test results for the following informatory tests for samples obtained from each of the proposed gravel source(s):

1.4.3.1 Gradation (ASTM C136)
1.4.3.2 Permeability (ASTM D2434)
1.4.3.3 Carbonate Content (ASTM D4373)

1.4.4 Construction Submittals.

During gravel placement submit test results for the following laboratory tests within 2 calendar days after testing is completed:

1.4.4.1 Gradation (ASTM C136)
1.4.4.2 Permeability (ASTM D2434)

1.4.5 Survey

Submit survey results for top of gravel in all areas of placement. Submit topographic survey drawings and survey data for the top surface of gravel within two calendar days after completion or at least two days prior to covering by subsequent layers. Submit survey results for top of gravel elevations at the following frequency at a minimum:

1.4.5.1 Cell bottoms - 50 foot grid and all grade breaks
1.4.5.2 Sumps - four corners and middle
1.4.5.3 Pipes - 1 per 50 linear foot

1.5 DELIVERY, STORAGE AND HANDLING

1.5.1 Gravel Material shall be stockpiled and protected from water and wind transported fines which may decrease the coefficient of permeability.

PART 2 - PRODUCTS

2.1 MATERIALS

2.1.1 Leachate Collection Gravel shall consist of:

2.1.1.1 Natural river or bank run gravel, free of silt, clay, friable or soluble materials, and organic matter, graded within the following limits:

U.S. Standard Sieve Size	Percent Passing by Weight
3/4-inch	100
3/8-inch	50 - 100
No. 4	30 - 100
No. 50	10 - 30
No. 100	0 - 10
No. 200	0 - 3

2.1.1.2 Leachate Collection and Leak Detection Gravel shall have a coefficient of permeability, determined using ASTM D2434, equal to or greater than 1 (one) centimeter per second when compacted to a relative density of 70 percent as determined by ASTM D4254. Subcontractor shall protect stockpiled gravel from dust, water or transported fines which may decrease the coefficient of permeability.

2.1.2 Graded filter gravel and sump gravel shall consist of:

2.1.2.1 Natural river or bank run gravel free of silt, clay, friable of soluble materials, and organic matter, graded within the following limits:

U.S. Standard Sieve Size	Percent Passing by Weight
1 1/2-inch	100
No. 4	0 - 30
No. 200	0 - 5

2.1.2.2 Leachate Collection and Leak Detection Pipe Graded Gravel shall have a coefficient of permeability, determined using ASTM D2434, equal to or greater than 30 centimeters per second when compacted to a relative density of 70 percent as determined by ASTM D4254. Subcontractor shall protect stockpiled gravel from dust, water or transport fines which may decrease the coefficient of permeability.

2.2 QUALITY CONTROL

2.2.1 All construction quality control sampling and testing shall be conducted by the QC Inspector in accordance with the specifications or as directed by the Construction Engineer. Testing and sampling procedures will be observed and documented by the CQAO.

2.2.2 Preconstruction Testing

2.2.2.1 Preconstruction Testing

Do not deliver gravel to site until the sampling and testing specified in this paragraph has been completed and the borrow source is approved by the Contractor. Samples shall be collected at the borrow source by the QC Inspector in the presence of the CQAO and shall be tested in accordance with the following test procedures and at the following frequencies;

Test	Test Procedures	Sampling Frequency
Gradation	ASTM C136	1 per 1500 cy
Hydraulic Conductivity (Tests performed at a relative density of 65 percent, as determined using ASTM D4254)	ASTM D2434	1 per 1500 cy
Carbonate Content	ASTM D4373	1 per 1500 cy

2.2.2.2 Field Quality Control Testing

Samples shall be collected by the QC Inspector in the presence of the CQAO after placement and compaction and shall be tested in accordance with the following test procedures and at the following frequencies:

Test	Test Procedure	Sampling Frequency
Gradation	ASTM C136	1 per 5000 cubic yards
Hydraulic Conductivity (Tests performed at a relative density of 65 percent, as determined under ASTM D4254).	ASTM D2434	1 per 5000 cubic yards

PART 3 - EXECUTION

3.1 PREPARATION

3.1.1 Subgrade Preparation

3.1.1.1 Examine the surface of the underlying geotextiles to ensure the surface is clean and free of debris.

3.2 PLACEMENT

3.2.1 Leachate Collection and Leak Detection Gravel:

3.2.1.1 Place gravel in a single layer to the lines and grades indicated on the Drawings.
3.2.1.2 Place gravel in the bottom of cell only after the ambient air temperature has been at or below 65 degrees F for a period of at least four hours.
3.2.1.3 Construction equipment shall not travel directly on the top of the liner system. Gravel shall be placed by pushing ahead of small size dozer with a ground pressure of less than 5 psi (D4 or equivalent). Tracked equipment shall be required where gravel is less than 2 feet thick.
3.2.1.4 The dozer shall place the gravel such that material is lifted and tumbled forward and such that excessive stress is not put on the geosynthetics.
3.2.1.5 Compact gravel layer with at least two passes of a small bulldozer.
3.2.1.6 Do not use equipment which may harm the underlying geosynthetics. Damage to the geosynthetics as a result of the Construction Subcontractor's activities shall be repaired at no additional cost to the Contractor.
3.2.1.7 Gravel shall be placed so that there is no "free drop" that exceeds 2 feet.
3.2.1.8 Place gravel by hand around pipes, appertances or in tight areas that restrict safe equipment acces.

3.2.1.9 Care shall be taken to avoid wrinkle formation. Small wrinkles shall be trapped by hand placement of gravel in advance of wrinkle. Any wrinkle in the geosynthetics large enough to fold over shall be considered an unacceptable condition, and shall be repaired at no cost to the Contractor.

3.3 TOLERANCES

3.3.1 As shown on drawings.

3.4 PROTECTION OF FINISHED WORK

3.4.1 Protect all gravel layers until subsequent layers are placed.

3.4.2 Gravel which becomes contaminated with fines exceeding the specified minimum shall be removed and replaced by the Construction Subcontractor at no additional cost to the Contractor.

END OF SECTION 02623

SECTION 02670

GEOMEMBRANE LINER SYSTEM

PART 1 - GENERAL

1.1 SECTION INCLUDES

1.1.1 Furnishing, installing, sampling, and testing high density polyethylene (HDPE) liners for the cell.

1.2 RELATED SECTIONS

1.2.1 Section 01300 - Submittals

1.2.2 Section 01400 - Quality Assurance/Quality Control

1.2.3 Section 02200 - Earthwork

1.2.4 Section 02680- Geosynthetic Clay Liner

1.2.5 Section 02710 - Leachate Collection and Leak Detection Systems

1.2.6 Construction Quality Assurance (CQA) Plan

1.3 REFERENCES

The latest issues of the following publications form a part of this Specification:

1.3.1 All references listed herein are incorporated as part of this Specification.

1.3.2 Construction Quality Assurance (CQA) Plan.

1.3.3 ASTM D638 - Standard Test Method for Tensile Properties of Plastic

1.3.4 ASTM D746 - Standard Test Method for Brittleness of Plastics and Elastomers by Impact

1.3.5 ASTM D751 - Standard Test Methods for Coated Fabrics

1.3.6 ASTM D1004 - Standard Test Method for Initial Tear Resistance of Plastic Film and Sheeting

1.3.7 ASTM D1204 - Standard Test Method for Linear Dimensional Changes of Nonrigid Thermoplastic Sheeting or Film at Elevated Temperature

1.3.8 ASTM D1238 - Standard Test Method for Flow Rates of Thermoplastics by Extrusion Plastometer

1.3.9 ASTM D1505 - Standard Test Method for Density Of Plastics by the Density -Gradient Technique

1.3.10 ASTM D1603 - Standard Test Method for Carbon Black in Olefin Plastics

1.3.11 ASTM D3015 - Standard Practice for Microscopical Examination of Pigment Dispersion in Plastic Compounds

1.3.12 ASTM D4437 - Standard Practice for Determining The Integrity of Field Seams Used in Joining Flexible Polymeric Sheet Geomembranes

1.3.13 FTMS 101C - " Puncture Resistance and Elongation Test (1/8 inch Radius Probe Method)", Federal Test Method 2065, March 13, 1980

1.4 DEFINITIONS

1.4.1 Contractor: Rocky Mountain Remediation Services

1.4.2 Geomembrane Manufacturer: The firm or party responsible for production of geomembrane for this project.

1.4.3 Geomembrane Subcontractor: The individual or firm, also referred to as "Installer", responsible for the geomembrane portions of the construction requirements.

1.5 SUBMITTALS

1.5.1 Submit in accordance with Section 1300: Submittals.

1.5.2 Product Data

The Construction Subcontractor shall submit the following at least 30-calendar days prior to construction:

1.5.2.1 Materials: Submit manufacturer's certification that materials meet the specified physical property specifications in Table 1 of paragraph 2.4. All properties listed shall be tested using the methods shown therein. Deviations from these test methods shall be explained in writing in this submittal.

1.5.2.2 Material Manufacturer: Submit certification indicating manufacturer meets the specified experience requirements in 1.5.6.1.

1.5.3 Shop Drawings

1.5.3.1 Seaming/Panel Layout Plan: Submit seaming/panel layout plan indicating proposed layout of seams/panels, deployment pattern and penetration details.

1.5.3.2 Pipe Penetration details. Submit shop drawings showing details for all pipe penetrations.

1.5.4 Quality Control Submittals

1.5.4.1 Pre-Qualification: The Construction Subcontractor shall submit the following:

1.5.4.1.1 Manufacturer's Installation Instructions.
1.5.4.1.2 The Installer's Quality Control Plan for geomembrane installation.
1.5.4.1.3 Example forms that will be used to document QC testing and inspection.

1.5.4.2 Pre-Installation: Prior to installation, the Construction Subcontractor shall submit the following:

1.5.4.2.1 Resume of the Geomembrane Superintendent and resume of the Master Seamer to be assigned to this project, including dates and duration of employment.
1.5.4.2.2 Installation schedule.
1.5.4.2.3 The origin supplier's name and production plant) and identification brand name and number) of the resin used to manufacture the geomembrane.
1.5.4.2.4 Copies of dated quality control certificates issued by the resin supplier.
1.5.4.2.5 Results of tests conducted by the Manufacturer to verify that the resin used to manufacture the geomembrane meets the project specifications.
1.5.4.2.6 A statement indicating that no reclaimed or recycled polymer or sheet material was added during the manufacturing of the geomembrane or of the rods/beads to be used on this project.
1.5.4.2.7 A list of the materials which comprise the geomembrane, expressed as a percentage by weight: polyethylene, carbon black, and other additives.
1.5.4.2.8 The Manufactures' geomembrane specification which shall include all properties contained in the project specifications, measured using the test methods specified herein.
1.5.4.2.9 Written certification that the minimum test values listed in the Manufacturer's specifications are guaranteed by the Manufacturer.
1.5.4.2.10 Quality control certificates, signed by a responsible party employed by the Manufacturer. Each quality control certificate shall include roll identification numbers, test procedures, and results of quality control tests. At a minimum, the quality control certificates shall list the following test results.

1.5.4.2.10.1 Density (ASTM D1505)
1.5.4.2.10.2 Carbon black content (ASTM D1603)
1.5.4.2.10.3 Carbon black dispersion (ASTM D3015)
1.5.4.2.10.4 Thickness (ASTM D751)
1.5.4.2.10.5 Tensile properties (ASTM D638)
1.5.4.2.10.6 Puncture resistance (FTMS 101B 2065)

1.5.4.2.11 Results of environmental stress crack resistance tests ASTM D1693 as modified by NFS 54). At a minimum, tests shall be performed once every resin lot.

1.5.4.2.12 Written certification that all resin used for the geomembrane and rods/beads used on this project are from the same resin batches). If the rods/beads are made from a different batch of resin than the geomembrane, submit certified test results indicating that the type of base polymer, composition crystallinity , and additives are equivalent for both materials.

1.5.4.2.13 Written certification that, in the case of textured geomembranes, the texturing is permanently adhered to the base geomembrane and will not delaminate during the warranty period.

1.5.4.3 Installation: During installation, the Construction Subcontractor shall submit:

1.5.4.3.1 Quality control documentation recorded during installation.

1.5.4.3.2 Subgrade acceptance certificates signed by the Installer's representative for each area to be covered by the geomembrane.

1.5.5 Contract Closeout Submittals

1.5.5.1 Upon completion of the installation, the Construction Subcontractor shall submit:

1.5.5.1.1 Panel Layout Record Drawing: A scaleable drawing indicating final seams/panels locations, repairs, and destructive test locations for all layers of geomembrane.

1.5.5.1.2 The warranty obtained from the manufacturer.

1.5.5.1.3 The installation warranty.

1.5.6 Previous Experience

1.5.6.1 Geomembrane Manufacturer:

1.5.6.1.1 The Geomembrane Manufacturer shall submit a list of at least five projects for which the geomembrane Manufacturer supplied a total of at least 20 million square feet of the same generic type of geomembrane to be used on this project. For each project, the following information shall be provided: name and purpose of the project, location, date, name of owner, designer, fabricator, installer, type of geomembrane, thickness, surface area, and available written information on the performance of the project.

1.5.6.2 Geomembrane Installer:

1.5.6.2.1 The Geomembrane Installer shall submit a list of at least three previous geomembrane installations totaling a minimum of 3 million square feet. For each installation, the following information shall be submitted: name and purpose of the project, location, date, name of owner, designer, manufacturer, fabricator and superintendent; type of geomembrane, thickness, surface area, type of seaming, duration of installation, and available written information on the performance of the project.

1.5.6.2.2 Submit documentation that the Geomembrane Installer is an approved and/or licensed installer for the Geomembrane Manufacturer.

1.5.6.2.3 Submit documentation attesting to at least 2 years experience for the Supervisor, Master Seamer, QC technician, and welding technicians that will perform work on this project.

1.6 WARRANTY

1.6.1 The Construction Subcontractor shall submit the warranties from the Manufacturer and the Installer as indicated in paragraph 1.5.5.1.2 and 1.5.5.1.2.

1.7 PROTECTION OF THE WORK

1.7.1 The installer shall use adequate measures to protect the geomembrane from damage due to wind, rain, or any other adverse conditions which could affect the integrity of the installation, until final inspection and acceptance by the Contractor.

1.8 QUALIFICATIONS

1.8.1 General

1.8.1.1 The Contractor will approve the Geomembrane Installer and the Geomembrane Manufacturer.

1.8.2 Geomembrane Installer

1.8.2.1 The Geomembrane Installer shall be trained and qualified to install the type of geomembrane to be used on this project. The Geomembrane Installer shall be an approved and/or licensed installer of the Geomembrane Manufacturer and/or Geomembrane Fabricator.

1.8.2.2 The Geomembrane Installer shall provide a Superintendent, Master Seamer, QC Technician, and Welding Technicians with a minimum of 2 years experience installing, seaming and testing HDPE liners.

1.8.3 Geomembrane Manufacturer

1.8.3.1 The geomembrane manufacturer shall demonstrates his ability to produce the geomembranes specified herein by having successfully manufactured a minimum of 5 million square feet of similar geomembrane material used for hydraulic and hazardous waste containment lining installations. The geomembrane manufacturer must be listed by the NSF National Sanitation Foundation) Standard 54 as meeting all requirements for manufacturing HDPE.

PART 2 - PRODUCTS

2.1 MATERIALS

2.1.1 The geomembrane shall be 80 mil and 100 mil thick textured and smooth conforming to the requirements specified herein.

2.1.2 The geomembrane shall be designed and manufactured specifically for the purpose of fluid containment. The geomembrane shall be free of holes, blisters, undispersed raw materials, and any sign of contamination by foreign matter.

2.1.3 The extrusion rod/bead material shall be provided from the identical manufacturer and shall be identical as the geomembrane liner material.

2.1.4 Material properties certifications shall be provided to the Contractor by the Construction Subcontractor or Geomembrane Manufacturer as an indication of the quality of the material supplied.

2.1.4.1 Material property certifications shall pertain to the geomembrane to be used for this project.
2.1.4.2 Certifications shall include all properties listed in Table 1 of this section.
2.1.4.3 The allowable range of properties listed in the certifications shall meet the specifications given in Table 1 of this section.
2.1.4.4 The certifications shall list minimum property values guaranteed by the Geomembrane Manufacturer and shall indicate the test methods performed.

2.1.5 Quality control certificates pertaining to the rolls of material delivered to the site shall accompany the rolls.

2.1.5.1 The Manufacturer shall identify all rolls of geomembranes with the following:

2.1.5.1.1 Manufacturer's name
2.1.5.1.2 Product identification
2.1.5.1.3 Thickness
2.1.5.1.4 Roll number
2.1.5.1.5 Roll dimensions

2.1.5.2 Quality control certificates shall include test results for the following tests:

2.1.5.2.1 Density ASTM D1505)
2.1.5.2.2 Carbon black content ASTM D1603)
2.1.5.2.3 Carbon black dispersion ASTM D3015)
2.1.5.2.4 Thickness ASTM D751)
2.1.5.2.5 Tensile properties ASTM D638)
2.1.5.2.6 Puncture resistance FTMS 101b 2065)

Each of these quality control tests shall be performed at a frequency of one per 50,000 square feet or geomembrane supplied for this project.

Results of environmental stress crack resistance tests ASTM 1693 as modified by NFS 54). At a minimum, tests shall be performed once every resin lot.

2.1.5.3 Test methods shall be in accordance with Table 1. The quality control certificates shall be signed by a responsible party employed by the Geomembrane Manufacturer, such as the production manager, and shall be notarized as or stamped by a registered professional engineer.

2.1.6 Seam Strength Requirements:

Geomembrane seams shall meet the following specifications:

Property	Qualifier	Unit	Specified Value	Test Method
Geomembrane Sheet Thickness	Min. Average	Mils	80 80 100 100 Smooth textured smooth textured	
Bonded Seam Strength	Min.	lb/in	166 151 207 189	ASTM D4437*
Peel Adhesion Fusion: Extrusion:	Min. Min.	lb/in lb/in	120 115 143 143 104 84 130 105	ASTM D4437* ASTM D4437*

* Test Methods modified as follows:
For shear tests the sheet shall yield before failure of the seam. For peel adhesion seam separation shall not extend more than 10 percent into the seam. For either test, testing shall be discontinued when the sample has visually yielded. All breaks shall be film tear bond FTB).

2.2 EQUIPMENT

2.2.1 GENERAL

Approved processes for field seaming are extrusions welding and fusion hot wedge) welding. This equipment shall meet the following requirements:

2.2.1.1 Extrusion Welder: The extrusion welding apparatus shall be equipped with gauges giving the temperatures at the nozzle and extruder barrel.

2.2.1.2 Fusion Welder: The fusion welding apparatus shall be an automated vehicular mounted device which produces a double seam with an enclosed space for air pressure testing. The fusion welding device shall be equipped with gauges giving the applicable temperatures and a speed control rheostat.

2.2.2 Testing

The following equipment shall be proved by the Geomembrane Installer for onsite seam testing shall be provided by the installer.

2.2.2.1 Tensiometer: The tensiometer shall be equipped with a gauge or digital display indicating pounds per inch in no more than one pound increments. the tensiometer shall have been calibrated with the last year and the calibration certificate shall accompany the tensiometer.

2.2.2.2 Die cutter: The die cutter shall be capable of cutting one inch coupons for seam testing.

2.3 SOURCE QUALITY CONTROL

2.3.1 The base resin shall be compounded and manufactured specifically for use in PE liners.

2.3.2 The base resin is the PE material prior to the addition of carbon black. The base ream shall meet the following requirements:

Test Description	Test Method	Required Range
Density	ASTM D1505	0.934 - 0.945 g/cm^3
Melt Index	ASTM D1238 Condition E	0.2 - 1.0 g/10 min

Table 1

GEOMEMBRANE: HIGH DENSITY POLYETHYLENE (HDPE)
MEETING THE FOLLOWING REQUIREMENTS

Test Description	Test Method	Unit	Smooth 80 mil	Textured 80 mil	Smooth 100 mil	Textured 100 mil
Sheet Thickness	ASTM D751	Mils	≥72 (marv)	≥72 (marv)	≥91 (marv)	≥91 (marv)
Force per unit width at yield	ASTM D638	lb/in	≥185 (marv)	≥185 (marv)	≥230 (marv)	≥230 (marv)
Force per unit width at break	ASTM D638	lb/in	≥320 (marv)	≥100 (marv)	≥400 (marv)	≥125 (marv)
Elongation at yield	ASTM D638	%	≥12 (marv)	≥12 (marv)	≥12 (marv)	≥12 (marv)
Elongation at break	ASTM D638	%	≥700 (marv)	≥150 (marv)	≥700 (marv)	≥150 (marv)
Tear strength	ASTM D1004	lbs	≥60 (marv)	≥60 (marv)	≥75 (marv)	≥75 (marv)
Puncture resistance	FTMS 101c 2065	lbs	≥105 (marv)	≥100 (marv)	≥130 (marv)	≥130 (marv)
Melt Index	ASTM D1238	gm/10 (marv)	.03 (max)	.03 (max)	.03 (max)	.03 (max)
Dimensional Stability each direction) maximum change	ASTM D1204, 100°C, 1 hour	% change	+/- 2%	+/- 2%	+/- 2%	+/- 2%
Environmental Stress Crack	ASTM D1693	hours	2000	2000	2000	2000
Low Temperature Brittleness	ASTM D746	Deg. C	≤-90°C	≤-90°C	≤-90°C	≤-90°C
Carbon Black Content	ASTM D1603	%	2-3% by weight	2-3% by weight	2-3% by weight	2-3% by weight
Density	ASTM D 505	g/cc	≥ 0.940 g/cc	≥ 0.940 g/cc	≥ 0.940 g/cc	≥ 0.940 g/cc
Carbon Black Dispersion	ASTM D3015 NSF Modified	NA	A-1, A-2, or B-1	A-1, A-2, or B-1	A-1, A-2, or B-1	A-1, A-2, or B-1

ASTM: American Society for Testing and Materials.

NSF: National Sanitary Foundation "Standards for Flexible Membrane Liners," Standard Number 54.

FTMS: Federal Test Method Standards

MARV: Minimum Average Roll Value

PART 3 - EXECUTION

3.1 PREPARATION

3.1.1 Prior to placing and installing geomembrane liner, examine area to receive geomembrane liner to confirm suitability for the installation of geomembrane liner material. The surface or the geosynthetic clay liner shall be inspected by the QC inspector. Any debris and/or rocks shall be removed.

3.2 INSTALLATION

3.2.1 Install according to the CQA Plan and the manufacturer's installation guide. The Manufacturer's installation guide shall include complete written instructions for storage, handling, installation, seaming, quality control and repair of geomembrane.

3.2.2 Should Manufacturers' installation guide conflict with construction package documents (e.g., CQA Plan), request clarification from Contractor before proceeding.

3.2.3 Installation shall not occur until the underlying layers have been accepted by the Contractor.

3.3 FIELD QUALITY CONTROL

3.3.1 TESTING

Testing of geomembrane trial seams, production seams and repairs shall be performed by a designated Quality Control technician in accordance with the CQA Plan.

3.3.2 Inspection

The Installer shall inspect his work for completeness.

END OF SECTION 02670

SECTION 02710

LEACHATE COLLECTION AND LEAK DETECTION
GEOTEXTILES, GEONETS, AND GEOPIPES

PART 1 - GENERAL

1.1 SECTION INCLUDES:

1.1.1 Furnish and install leachate collection and leak detection systems, geotextiles, geonets, geocomposites, and geopipes in the cell.

1.2 RELATED SECTIONS

1.2.1 Section 01300 - Submittals

1.2.2 Section 01400 - Quality Assurance/Quality Control

1.2.3 Section 02200 - Earthwork

1.2.4 Section 02670 - Synthetic Liner System

1.2.5 Section 02722 - Site Storm Sewer Systems

1.2.6 Construction Quality Assurance Plan (CQA Plan)

1.3 REFERENCES

The latest issues of the following publications form a part of this Specification:

1.3.1 All references listed herein are incorporated as part of this Specification.

1.3.2 ASTM D1505 - Density of Plastics

1.3.3 ASTM D751 - Standard Test Method for Coated Fabrics

1.3.4 ASTM D638 - Standard Test Method for Tensile Properties of Plastics

1.3.5 ASTM D4833 -Standard Test Method for Index Puncture Resistance of Geotextiles, Geomembranes and Related Products

1.3.6 ASTM D5321 - Determining the coefficient of soil and geosynthetic or geosynthetic and geosynthetic friction by direct shear method.

1.4 SUBMITTALS

1.4.1 At least 30 calendar days prior to the installation of any geotextile or geonet, the Construction Subcontractor shall submit the following information:

1.4.1.1 The origin (resin supplier's name and resin production plant), identification (brand name and number), and production date of the resin.

1.4.1.2 Copies of the quality control certificates issued by the resin supplier.

1.4.1.3 Reports on tests conducted by the Manufacturer to verify that the quality of the resin used to manufacture the geotextile and geonet meets the project construction specifications.

1.4.1.4 Reports on quality control tests conducted by the Manufacturer to verify that the geotextile and geonet manufactured for the project meets the project construction specifications.

1.4.1.5 A statement indicating that no recycled or reclaimed polymer was added to the resin during manufacturing.

1.4.1.6 A list of the materials which comprise the geotextile and geonet, expressed as percent by weight for polyethylene, carbon black, and other additives.

1.4.1.7 A specification for the geotextile and geonet which includes all properties contained in the project specifications measured using the appropriate test methods.

1.4.1.8 Written certification that minimum values given in the manufacturer's specification are guaranteed to meet the specifications by the Manufacturer.

1.4.1.9 Quality control certificates, signed by a responsible party employed by the Manufacturer. The quality control certificates shall include roll identification numbers, sampling procedures and results of quality control tests. Quality control tests shall be performed according to the test methods specified herein, at the following frequencies: every 100,000 ft^2 (10,000 m^2) of geotextile and every 40,000 ft^2 (4,000 m^2) of geonet produced. At a minimum, test results shall be submitted for:

Geonet:

1.4.1.9.1 Density ASTM D1505

1.4.1.9.2 Tensile strength MD ASTM D1682

1.4.1.9.3 Thickness ASTM D751

1.4.1.9.4 Carbon black content D1603

Geotextile:

1.4.1.9.5 Mass per unit area ASTM D3776

1.4.1.9.6 Grab strength ASTM D4632

1.4.1.9.7 Trapezoidal tear strength ASTM D4533

1.4.1.9.8 Burst strength ASTM D3786

1.4.1.9.9 Puncture strength ASTM D4833

1.4.1.9.10 Permittivity ASTM D4491

1.4.1.10 Manufacturers installation instructions for geotextile, geonet, geocomposite and geopipes.

1.4.2 At least 30 calendar days prior to the installation of any geocomposite, the Construction Subcontractor shall submit the following information:

1.4.2.1 The origin (supplier's name and production plant) and identification (brand name and number) of the geotextile and geonet used to fabricate the geocomposite.

1.4.2.2 Copies of dated quality control certificates issued by the geotextile and geonet supplier. These certificates shall contain the results of the quality control tests performed on the geocomposite components outlined in Section 1.4.A.9.

1.4.2.3 A specification for the geocomposite which includes all properties published by the Manufacturer measured using the appropriate test methods.

1.4.2.4 QC test data provided by the Manufacturer supporting that the material property values of the materials delivered meet the manufacturer's specifications.

1.4.2.5 Quality control certificates for the geocomposite, signed by a responsible party employed by the Manufacturer. The quality control certificates shall include roll identification numbers, testing procedures and results of quality control tests. Quality control tests shall be performed in accordance with the test methods identified, at least every 40,000 ft^2 of geocomposite produced. At a minimum, test results shall be submitted for:

1.4.2.5.1 Geotextile-geonet adhesion (ASTM F904 2" x 5" 2IPM)

1.4.2.6 Test results of laboratory direct shear tests certifying that there is no geosynthetic to geosynthetic interface in the cell side slope lining system with an interface friction angle less than 22 degrees. Direct shear tests will be performed in accordance with ASTM D5321. Each test (e.g. each different interface tested) will consist of at least three points: one at a confining pressure of 1 psi, one at a confining pressure of 2 psi, and one at a confining pressure of 3 psi. A constant shearing rate of 0.2 in./min. will be used with sufficient total displacement to develop residual shear strength conditions (approximately 1 to 3 inches per ASTM D5321). The interfaces tested will consist of:

1.4.2.6.1 Geocomposite/textured HDPE geomembrane. One test for each different combination of geocomposite geotextile/textured HDPE geomembrane. (Only one test required if all geotextile layers are the same and all HDPE texturing is the same). These tests will be conducted under saturated conditions.

1.4.2.6.2 GCL (bentonite side)/textured HDPE geomembrane. Only one test required provided all interfaces have same texturing. These tests will be performed "dry" (i.e. at ambient moisture conditions with GCL at moisture content as received from manufacturer).

1.4.3 At least 30 calendar days prior to installing geopipe, submit:

1.4.3.1 Product data which indicates that the geopipe meets the requirements of paragraph 2.1.

1.4.3.2 Procedures proposed for use in HDPE pipe installation and HDPE pipe welding shall be submitted to the Contractor for Approval prior to initiating the work.

PART 2 - PRODUCTS

2.1 GEOPIPE

2.1.1 Leachate collection and leak detection system pipe shall conform to the following minimum material specifications for HDPE Pipe:

Property	ASTM Reference	Nominal Value	Unit
Density (pipe)	D 1505	0.955	g/cm³
Density (natural base resin)	D 1505	0.945	g/cm³
Melt Index, condition E	D 1238	0.1-0.2	g/10 min.
Melting Point (Vicat Softening Temperature)	D 1525	255	°F
Brittleness Temperature	D 746	<-180	°F
Thermal Expansion	D 696	$9X10^{-5}$	in/in/°F
Thermal Conductivity	C 177	2.7	Btu-in/ft²/hr/°F
Tensile Strength, yield (2.0 in/min.)	D 638	>3200	psi
Tensile Strength, ultimate (2.0 in/min.)	D 638	≥5000	psi
Elongation (2.0 in/min.)	D 638	≥800	percent
Modulus of Elasticity	D 638	110,000	psi
Flexural Modulus	D 3350	125,000	psi
Long Term Hydrostatic Strength (LTHS)	D 2837	1600	psi
Hydrostatic Design Basis (HDB)	D 2837	1600	psi
Hardness - Shore D	D 2240	66	--
Environmental Stress Crack Resistance (ESCR), condition C	D 1693	>5000	hrs.

2.1.2 HDPE Pipe shall meet the following minimum requirements:

Specified Size (in.)	Min ID (in.)	Max SDR*
2	1.9	11
4	3.6	11
6	5.7	17
8	7.5	26
12	11.1	26
24	22.1	26

* SDR = Standard Dimension Ratio; = Pipe OD/Pipe Thickness.

2.1.3 Perforate pipe as shown on drawings.

2.2 PROTECTIVE AND FILTER GEOTEXTILE FABRICS

2.2.1 The geotextile separation, protective cushion, filter and friction fabrics shall be nonwoven sheets formed of thermally bonded or needle punched continuous filaments of preferentially orientated isotactic polypropylene or polyester.

2.2.2 Geotextile friction fabric shall be Trevira 011/280 or equal.

2.2.3 Geotextile separation and protective Cushion Fabric shall be Trevira 011/550 or equal.

2.2.4 Geotextile filter fabric shall be Trevira 011/450 or equal.

2.2.5 The fabric shall be a minimum of 12 feet wide and free of defects or flaws which significantly affect its properties and shall meet the following requirements:

		Required Values		
Property	ASTM Test Method	Separation/ Protective Cushion Fabric	Filter Fabric	Geocomposite Friction Fabric
Weight	D 3776-84	16 oz/yd^2	13 oz/yd^2	8 oz/yd^2
Grab Strength	D 4632-91	≥ 500 lbs.	≥ 390 lbs.	≥ 230 lbs.
Grab Elongation	D 4632-91	≥ 70%	≥ 65%	≥ 60%
Trapezoid Tear Strength	D 4533-85	≥ 150 lb.	≥ 130 lb.	≥ 80 lb.
Puncture Resistance	D 4833	≥ 195 lb.	≥ 155 lb.	≥ 100 lb.
Mullen Burst Strength	D 3786	≥ 780 psi	≥ 640 psi	≥ 380 psi
Permittivity	D 4491-92	0.53 sec^{-1}	0.80 sec^{-1}	1.20 sec^{-1}
Apparent opening size(A.O.S.)	D 4751	100(US Sieve)	100(US Sieve)	70(US Sieve)
		≤ 0.149 mm	≤ 0.149 mm	≤ 0.210 mm

2.3 GEONET

2.3.1 The geonet shall be profiled mesh formed by extruding two sets of HDPE strands together.

2.3.2 Minimum 7 feet wide, free of defects or flaws which significantly affect its properties, shall meet the following requirements:

Property	ASTM Method	Required Values
Carbon Black Content	D 1603	2 to 3%
Nominal Thickness	D 751	≥ 0.16 inches
Density	D 1505	≥ 0.940
Nominal Transmissivity*	D 4716	≥ 5 x 10^{-3} ft^2/sec
Tensile Strength MD	D 1682	≥ 25 lb/in

* 5,000 psf confining pressure test set up with: Plate/Geo composite consisting of: 13 oz geotextile; geonet; 8 oz geotextile/plate

2.4 GEOCOMPOSITE

2.4.1 The geocomposite in the leachate collection system of the cell side slopes shall be a geonet bonded between an 8 oz. friction geotextile. (Trevira 011/280 or equivalent) and a 13 oz. filter geotextile. (Trevira 011/450 or equivalent). This geocomposite is installed with the 13 oz. filter geotextile facing upward.

2.4.2 The geocomposite in the leak detection system of the cell shall be a geonet bonded between two 8 oz. friction geotextiles (Trevira 011/280 or equivalent).

2.4.3 The geonet/geotextile components of the geocomposite shall meet all of the material properties required for the separate components. Refer to paragraph 2.2 and 2.3. In addition to these requirements the geonet/geotextile composite shall meet the following:

Property	ASTM Method	Specification
Peel Adhesion	F-904	1.2 lb/in minimum

PART 3 - EXECUTION

3.1 PREPARATION

3.1.1 Verify all lines and grades of field conditions are as shown on the Drawings.

3.1.2 Verify that all surfaces have been properly prepared prior to installation of the leachate collection and leachate detection system.

3.2 INSTALLING LEACHATE COLLECTION SYSTEM

3.2.1 The leachate collection system riser shall be installed and constructed in accordance with the lines, grades, dimensions, and cross sections shown on the drawings and as required by these specifications.

3.2.2 Installing Riser Pipe

3.2.2.1 The HDPE riser pipe (casing) shall be installed to the design lengths indicated on the drawings in a work area to be designated by the Contractor.

3.2.2.2 Positive anchorage of the riser pipe to prevent pipe movement during backkilling is required.

3.2.2.3 The HDPE riser pipe shall be slotted in accordance with the dimensions shown on the drawings and in accordance with manufacturers recommendations.

3.2.2.4 The HDPE riser pipe shall be placed against the prepared surface of the slope excavation using suitable equipment in a manner approved by the Contractor and in accordance with the manufacturers recommendations. The HDPE riser pipe shall be anchored at the top with a ballast approved by the Construction Engineer.

3.2.2.5 Synthetic membranes shall be constructed around the riser pipe as shown in the drawings and in accordance with the requirements of these specifications.

3.2.3 Excavating Riser Pipe Trench

3.2.3.1 The riser pipe trench for the leak detection system shall be excavated along the slope of the excavation to the grades, dimensions, cross-sections, and details shown on the drawings or as directed by the Contractor.

3.2.3.2 Excavate utilizing suitable equipment in a manner approved by the Contractor.

3.2.4 Installing Sump Discharge Conduit

3.2.4.1 Install HDPE pipe sump discharge conduit along alignment shown on the Drawings.

3.2.4.2 Provide temporary cap for cell end of conduit.

3.2.5 Placing Riser Pipe Bedding

3.2.5.1 Bedding material may be utilized on the prepared surface beneath the HDPE riser pipe to facilitate pipe placement as well as the placement and compaction of the backfill materials. Refer to Section 02200 - Earthwork, for pipe bedding material and placement requirements.

3.2.5.2 Soil designated as "Class 3 Common Fill" shall be used as backfill around the pipe. "Class 3 Common Fill" shall be placed and compacted as specified in Section 02200 - Earthwork.

3.2.5.3 Backfill placed and compacted to thicknesses or grades in excess of that on either side of the riser pipe trench shall be trimmed by approved measures to conform with the surrounding grades.

3.2.6 Installing Geonet

3.2.6.1 The Manufacturer's installation guide, which shall include complete written instructions for storage, handling, installation, seaming, quality control and repair of geonet, shall be referenced and followed for all aspects of geonet construction/installation.

3.2.6.2 Should manufacturer's instructions conflict with construction package, request clarification from Construction Engineer before proceeding.

3.2.6.3 The Construction Subcontractor shall examine the surface of the geoemembrane to make sure it is free of dust or dirt prior to the installation of geonets, geotextiles, and geocomposites.

3.2.6.4 At a minimum, the following requirements for joining the adjacent geonet shall be met:

3.2.6.4.1 Adjacent rolls shall be overlapped by at least 4 inches.

3.2.6.4.2 The geonet overlaps shall be tied with plastic fasteners. Tying devices shall be white or yellow for easy inspection. Metallic devices are not allowed.

3.2.6.4.3 Tying shall be every 5 ft along the length at the adjacent rolls, every 6 inches in the anchor trench and every 6 inches along end-to-end seams.

3.2.6.4.4 In general, no horizontal seams shall be allowed on sideslopes.

3.2.6.4.5 In the corners of the sideslopes of rectangular landfills, where overlaps between perpendicular geonet strips are required, an extra layer of geonet shall be unrolled along the slope, on top of the previously installed geonet, from top to bottom of the slope.

3.2.6.4.6 When more than one layer of geonet is installed, joints shall be staggered.

3.2.6.4.7 When several layers of geonet are stacked, rolls shall be deployed in the same direction to prevent strands of one layer from penetrating the channels of the adjacent layer.

3.2.6.5 Any holes on tears in the geonet shall be repaired using one of the following procedures:

3.2.6.5.1 If a hole or tear width is less than 50% of the width of the roll, the damaged area shall be repaired as follows:

- A patch shall be placed extending 1 ft beyond the edges of the hole or tear.
- The patch shall be secured to the original geonet by tying every 6 inches. Tying devices shall be as indicated in paragraph 3.2.F.3.b.

3.2.6.5.2 If a hole or tear width across the roll is equal to or more than 50% of the width of the roll, the damaged area shall be repaired as follows:

- At the base of the cell, the damaged area shall be cut out and the two portions of the geonet shall be joined as indicated in Paragraph 3.2.F.3.
- On sideslopes, the damaged geonet roll shall be removed and replaced.

3.2.7 Installing Geotextiles

3.2.7.1 The Manufacturer's installation guide, which shall include complete written instructions for storage, handling, installation, seaming, quality control and repair of geotextile shall be referenced and followed for all aspects of geotextile construction/installation.

3.2.7.2 Should manufacturer's instructions conflict with construction package, request clarification from Construction Engineer before proceeding.

3.2.7.3 At a minimum, the following requirements shall be met.

3.2.7.3.1 Geotextiles shall be overlapped a minimum of 3 in (75 mm) prior to seaming. In general, no horizontal seams shall be allowed on sideslopes (seams along, not across, the slope) except as part of a patch. When horizontal seams are necessary, adjacent seams shall be staggered horizontally.

3.2.7.3.2 On slopes steeper than 10:1 (horizontal:vertical), all geotextiles shall be continuously sewn. Spot sewing is not allowed. On bottoms and slopes shallower than 10: 1, geotextiles shall be continually sewn or thermally bonded with the written approval of the Construction Engineer.

3.2.7.3.3 Any sewing shall be done using polymeric thread with chemical and ultraviolet light resistance properties equal to or exceeding those of the geotextile. The color of the sewing thread shall contrast the background color of the geotextile.

3.2.7.3.4 Any holes or tears in the geotextile shall be repaired using the following two procedures.

- On sideslopes, a patch made from the same geotextile shall be thermally bonded or sewn into place in accordance with the project specifications. Should any tear exceed 10% of the width of the roll, that roll shall be removed from the slope and replaced.
- On non-sideslope areas, a patch made from the same geotextile shall be thermally bonded or sewn into place with a minimum of 12-inch overlap in all directions. Care shall be taken to remove any soil or other material which may have penetrated the torn geotextile.

3.2.7.4 A visual examination of the geotextile shall be carried out over the entire surface, after installation, to ensure that no potentially harmful foreign objects, such as needles, are present.

3.2.8 Installing Geocomposite

3.2.8.1 The Manufacturer's installation guide, which shall include complete written instructions for storage, handling, installation, seaming, quality control and repair of geocomposite, shall be referenced and followed for all aspects of geocomposite construction/installation.

3.2.8.2 Should manufacturers' instructions conflict with construction package, request clarification from Construction Engineer before proceeding.

3.2.8.3 Joining, seaming and repair of geocomposite shall follow the specifications for the individual components. Refer to paragraphs 3.2F and 3.2G.

3.3 INSTALLING LEAK DETECTION SYSTEM

3.3.1 The leak detection system riser pipes for the cell installed shall be installed and constructed in accordance with the lines, grades, dimensions, shown on the drawings and as required in these specifications. Installation shall be as for the leachate collection system riser pipes refer to paragraph 3.2.B.

3.3.2 End caps shall be provided on the lower end of the leak detection sump riser pipes.

3.3.3 The HDPE riser pipe shall be anchored at the top of the berm with a concrete pad as shown on drawings.

3.4 INSTALLING GEONET AND GEOTEXTILE ON SUMP RCP RISER

3.4.1 Wrap the RCP riser with a minimum of 3 wraps of geonet and secure with typing devices as specified in 3.2F on 6 inch spacing.

3.4.2 Wrap 13 oz geotextile around geonet once and overlap a minimum of 2 feet. Heat bond the geotextile overlap.

3.5 FIELD QUALITY CONTROL

3.5.1 HDPE Pipe

3.5.1.1 Visually inspect all HDPE pipe couplings.

3.5.2 Geonets, geotextiles and geocomposites.

3.5.2.1 Visually inspect all seams, overlaps and repairs.
3.5.2.2 Inspect work for completeness.

END OF SECTION 02710

SECTION 03300

CAST-IN-PLACE CONCRETE

PART 1. - GENERAL

a. SECTION INCLUDES

i. Cast-in-place concrete foundation walls.

ii. Floors and slabs on grade.

iii. Control, and expansion and contraction joint devices associated with concrete work, including joint sealants.

iv. Equipment pads.

b. REFERENCES

i. All references listed herein are incorporated as part of this Specification.

ii. ACI 301 - Structural Concrete for Buildings.

iii. ACI 302 - Guide for Concrete Floor and Slab Construction.

iv. ACI 304 - Recommended Practice for Measuring, Mixing, Transporting and Placing Concrete.

v. ACI 305R - Hot Weather Concreting.

vi. ACI 306R - Cold Weather Concreting.

vii. ACI 308 - Standard Practice for Curing Concrete.

viii. ACI 318 - Building Code Requirements for Reinforced Concrete.

ix. ANSI/ASTM D994 - Preformed Expansion Joint Filler for Concrete (Bituminous Type).

x. ANSI/ASTM D1190 - Concrete Joint Sealer, Hot-Poured Elastic Type.

xi. ANSI/ASTM D1751 - Preformed Expansion Joint Fillers for Concrete Paving and Structural Construction (Nonextruding and Resilient Bituminous Types).

xii. ANSI/ASTM D1752 - Preformed Sponge Rubber and Cork Expansion Joint Fillers for Concrete Paving and Structural Construction.

xiii. ASTM C33 - Concrete Aggregates.

xiv. ASTM C94 - Ready-Mixed Concrete.

xv. ASTM C150 - Portland Cement.

xvi. ASTM C260 - Air Entraining Admixtures for Concrete.

xvii. ASTM C494 - Chemicals Admixtures for Concrete.

c. SUBMITTALS

i. Submit under provisions of Section 01300.

ii. Product Data: Provide data on joint devices, attachment accessories, admixtures.

iii. Samples: Submit two inch long samples of expansion/contraction joint and control joint.

iv. Manufacturer's Installation Instructions: Indicate installation procedures and interface required with adjacent Work.

v. Concrete Mix Designs for all application required for this project.

vi. Test Results of all tests performed under this specification section.

d. PROJECT RECORD DOCUMENTS

i. Submit under provisions of Section 01300.

ii. Accurately record actual locations of embedded utilities and components which are concealed from view.

e. QUALITY ASSURANCE

i. Perform Work in accordance with ACI 301.

ii. Acquire cement and aggregate from same source for all work.

iii. Conform to ACI 305R when concreting during hot weather.

iv. Conform to ACI 306R when concreting during cold weather.

f. COORDINATION

i. Coordinate the placement of joint devices with erection of concrete formwork and placement of form accessories.

PART 2. - PRODUCTS

a. CONCRETE MATERIALS

i. Cement: ASTM C150, Type I - Normal.

ii. Fine and Coarse Aggregates: ASTM C33, maximum coarse aggregate size of 1 inch.

iii. Water: Clean and not detrimental to concrete.

b. ADMIXTURES

i. Air Entrainment: ASTM C260.

ii. Chemical: ASTM C494, Type A - Water Reducing Type B -Retarding Type C - Accelerating Type D - Water Reducing and Retarding Type E - Water Reducing and Accelerating.

iii. Do not utilize admixtures at locations where water repellants and hardeners are to be applied unless specifically recommended by surface treatment manufacturers.

c. ACCESSORIES

i. Non-Shrink Grout: Premixed compound consisting of non-metallic aggregate, cement, water reducing and plasticizing agents; capable of developing minimum compressive strength of 2,400 psi in 48 hours and 7,000 psi in 28 days.

d. JOINT DEVICES AND FILLER MATERIALS

i. Joint Filler: ASTM D1751, ASTM D994; Asphalt impregnated fiberboard or felt, 1/4 inch thick; tongue and groove profile.

ii. Construction Joint Devices: Integral galvanized steel 1 1/2 inch thick, formed to tongue and groove profile, with removable top strip exposing sealant trough, knockout holes spaced at 6 inches ribbed steel spikes with tongue to fit top screed edge.

iii. Sealant and Primer: Polyurethane type, as specified in Section 07900.

e. CONCRETE MIX

i. Mix concrete in accordance with ACI 304. Deliver concrete in accordance with ASTM C94.

ii. Select proportions for normal weight concrete in accordance with ACI 301 Method 1.

iii. Provide concrete to the following criteria:

(1) Compressive Strength (28 days): 4000 psi

(2) Slump: 1 to 3 inches.

(3) Minimum Water/Cement Ratio: 0.43.

iv. Use accelerating admixtures in cold weather only when approved by Contractor. Use of admixtures will not relax cold weather placement requirements.

v. Use calcium chloride only when approved by Contractor.

vi. Use set retarding admixtures during hot weather only when approved by Contractor.

vii. Add air entraining agent to normal weight concrete mix. Entrained air content shall be 6 pecent $\pm$ 1 1/2 percent.

PART 3. - EXECUTION

a. EXAMINATION

i. Verify requirements for concrete cover over reinforcement.

ii. Verify that anchors, reinforcement and other items to be cast into concrete are accurately placed, positioned securely, and will not cause hardship in placing concrete.

b. PREPARATION

i. Prepare previously placed concrete by cleaning with steel brush and applying bonding agent in accordance with manufacturer's instructions.

ii. In locations where new concrete is dowelled to existing work, drill holes in existing concrete, insert steel dowels and pack solid with non-shrink grout.

c. PLACING CONCRETE

i. Place concrete in accordance with ACI 304, ACI 301 and ACI 318.

ii. Place concrete in forms within 90 minutes of beginning mixing.

iii. Cold Weather Placement: When depositing concrete after the first frost or when mean daily temperature is below 40 degrees F follow recommendation of ACI 306R.

iv. Hot Weather Placement: When depositing concrete in hot weather, follow recommendation of ACI 305R. The optimum temperature of concrete at time of placement shall not exceed 85 degrees F. Protect to prevent rapid drying. Start finishing and curing as soon as possible. When the air temperature is expected to exceed 90 degrees F, the Sub-Contractor shall obtain approval from the Contractor on the procedures to be used in protection, depositing, finishing, and curing of concrete.

v. Notify Contractor minimum 24 hours prior to commencement of operations.

vi. Ensure reinforcement, inserts, embedded parts, formed joint fillers and joint devices are not disturbed during concrete placement.

vii. Install joint fillers, in accordance with manufacturer's instructions.

viii. Separate slabs on grade from vertical surfaces with 1/2 inch thick joint filler.

ix. Extend joint filler from bottom of slab to within 1/2 inch of finished slab surface.

x. Install joint devices in accordance with manufacturer's instructions.

xi. Install construction joint device in coordination with floor slab pattern placement sequence. Set top to required elevations. Secure to resist movement by wet concrete.

xii. Install joint device anchors. Maintain correct position to allow joint cover flush with floor and wall finish.

xiii. Install joint covers in longest practical length, when adjacent construction activity is complete.

xiv. Maintain records of concrete placement. Record date, location, quantity, air temperature, and test samples taken.

xv. Place concrete continuously between predetermined expansion, control, and construction joints.

xvi. Do not interrupt successive placement; do not permit cold joints to occur.

xvii. Place floor slabs in checkerboard pattern.

xviii. Saw cut joints within 24 hours after placing. Using 3/16 inch thick blade, cut into 1/4 depth of slab thickness.

xix. Screed slabs on grade level, maintaining surface flatness of maximum 1/4 inch in 10 ft.

d. CONCRETE FINISHING

i. Provide formed concrete surfaces to be left exposed with smooth rubbed finish.

ii. Finish concrete floor surfaces to requirements of Section 03346.

e. CURING AND PROTECTION

i. Immediately after placement, protect concrete from premature drying, excessively hot or cold temperatures, and mechanical injury.

ii. Maintain concrete with minimal moisture loss at relatively constant temperature for period necessary for hydration of cement and hardening of concrete.

iii. Cure concrete floor surfaces to requirements of Section 03370.

f. FIELD QUALITY CONTROL

i. Field inspection and testing will be performed in accordance with ACI 301 and under provisions of Section 01400.

ii. Provide free access to Work and cooperate with appointed firm.

iii. Submit proposed mix design of each class of concrete to inspection and testing firm for review prior to commencement of Work.

iv. Tests of cement and aggregates may be performed to ensure conformance with specified requirements.

v. Three concrete test cylinders will be taken for every 25 yards of concrete delivered each day and for each separate placement of concrete exceeding 3 cu. yds.

vi. One additional test cylinder will be taken during cold weather concreting, cured on job site under same conditions as concrete it represents.

vii. One slump test, entrained air test, and temperature will be taken for each truck delivery to the site.

g. PATCHING

i. Allow Contractor to inspect concrete surfaces immediately upon removal of forms.

ii. Excessive honeycomb or embedded debris in concrete is not acceptable. Notify Contractor upon discovery.

iii. Patch imperfections in accordance with ACI 301.

h. DEFECTIVE CONCRETE

i. Defective Concrete: Concrete not conforming to required lines, details, dimensions, tolerances or specified requirements.

ii. Repair or replacement of defective concrete will be determined by the Contractor.

iii. Do not patch, fill, touch-up, repair, or replace exposed concrete except upon express direction of the Contractor for each individual area.

END OF SECTION 03300

Appendix B-3: Designation Support Documentation

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SECTION B-3.1

CLOSURE AND POST CLOSURE PLAN OUTLINE FOR THE REMEDIATION WASTE STORAGE FACILITY

Revision 0
June, 1997

Outline

INTRODUCTION

This Closure and Post-Closure Plan Outline has been prepared as an appendix to the Corrective Action Management Unit (CAMU) Decision Document (DD) in support of the designation of a CAMU to facilitate the final remedy of offsite disposal for cleanup of the Rocky Flats Environmental Technology Site (RFETS), located in Jefferson County, Colorado. This facility is anticipated to be clean closed by removal and offsite disposal of all remediation wastes and contaminated structural material. Minimal post-closure care, if any, is anticipated.

PURPOSE AND SCOPE

The DD, including this appendix, will be submitted to Colorado Department of Public Health and Environment (CDPHE) as a basis for designation of the CAMU. This outline presents the Closure and Post-Closure Plan Outline for the CAMU at RFETS. This Closure and Post-Closure Plan was prepared in accordance with the Colorado Hazardous Waste Regulations found at 6 Code of Colorado Regulations (CCR) 1007-3, Section 264.552. Although not specifically required by 6 CCR 1007-3, Section 264.552, this Closure Plan uses as guidance many of the elements for closure and post-closure care specified in 6 CCR 1007-3, Part 265, Subpart G (Closure and Post Closure).

This Closure Plan will include post-closure care activities, as necessary, for the RWSF. The language in 6 CCR 1007-3 Section 264.552 requires that areas within the CAMU where remediation wastes remain in-place after closure of the CAMU be managed and contained to control, minimize, or eliminate future releases to the extent necessary to protect human health and the environment. The RWSF will not have hazardous waste remain in place after closure.

The facilities within the CAMU will not likely require post-closure care because waste and contaminated facility material will be removed from these facilities and the facilities will be decontaminated during closure.

Section 2.0 of this Closure Plan will present a general description of the RWSF facility and the facilities within the CAMU undergoing closure. Section 3.0 will present a general discussion of the closure procedures and the associated waste management activities that will occur during closure. Section 4.0 will describe the anticipated schedule for closure activities, and Section 5.0 will provide a Post-Closure Plan if necessary. Section 6.0 will provide a list of acronyms, and Section 7.0 will provide the reader with a list of references used in the document.

This Closure and Post-Closure Plan Outline provides a framework for the final closure and post-closure of facilities within the CAMU. The final closure and post-closure plan will be developed during the Title II Design phase and submitted with the Title II Design package. All future closure and post-closure plans will be submitted to CDPHE for approval.

CLOSURE PROCEDURES

It is the intent that closure activities will be performed to meet the closure standards specified in 6 CCR 1007-3, Section 264.552. The components of closure procedures presented in this section use as guidance many of the elements for closure specified in 6 CCR 1007-3, Part 265, Subpart G. The closure of the RWSF will be conducted in a manner that:

- Minimizes the need for further maintenance; and

- Control, minimizes or eliminates, to the extent necessary to protect human health and the environment, post-closure escape of hazardous waste, hazardous constituents, leachate, contaminated run-off, or hazardous waste decomposition products to the ground or surface waters or to the atmosphere.

The components of closure described in this Closure Plan Outline and further developed during design will provide long-term protection of human health and the environment. Closure of the CAMU will include the following:

- Removal of wastes stored in the RWSF
- Decontamination of the RWSF
- Requirements for removal and decontamination of equipment, devices, and structures used in remediation waste management activities within the CAMU.
- Requirements for excavation, removal, treatment, or containment of hazardous wastes.

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SECTION B-3.2

TEST FILL CERTIFICATION REPORT OUTLINE FOR THE REMEDIATION WASTE STORAGE FACILITY (RWSF)

Revision 0
June, 1997

Test Fill Certification Report Outline

1.0 INTRODUCTION

1.1 Purpose And Scope

1.2 Background

2.0 CLAY BORROW MATERIAL EVALUATION

3.0 DETERMINATION OF THE ACCEPTABLE ZONE

4.0 TEST FILL CONSTRUCTION

4.1 General

4.2 Subgrade Preparation

4.3 On-Site Processing And Placement Of Clay

4.4 Compaction

5.0 TEST FILL CONSTRUCTION DOCUMENTATION

5.1 General

5.2 Survey Control

5.3 Sampling And Testing Program
- 5.3.1 General
- 5.3.2 Laboratory Compaction Tests
- 5.3.3 In-place Destiny and Moisture Content Tests
- 5.3.4 Shelby Tube/Block Samples and Tests
- 5.3.5 Sealed Double Ring Infiltrometer Tests
- 5.3.6 Test Pits

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1.0 INTRODUCTION

A test pad will be constructed to demonstrate compliance with soil material hydraulic conductivity requirements listed in 6 CCR 1007-3 264.301.

Borrow sources will be identified once it has been determined that the CAMU RWSF will be constructed.

Successful test fill demonstration has occurred previously at RFETS during construction of the New Sanitary Landfill.

2.0 TEST PAD PROCESS OVERVIEW

The information presented below is based upon Quality Assurance and Quality Control for Waste Containment Facilities EPA/600/R-93/182 September 1993.

2.1 Purpose of Test Pads

The purpose of a test pad is to verify that the materials and methods of construction proposed for a project will lead to a soil liner with the required large-scale, in-situ, hydraulic conductivity. Unfortunately, it is impractical to perform large-scale hydraulic conductivity tests on the actual soil liner for two reasons: (1) the testing would produce significant physical damage to the liner, and the repair of the damage would be questionable; and (2) the time required to complete the testing would be too long -- the liner could become damaged due to desiccation while one waited for the test results.

A test pad may also be used to demonstrate that unusual materials or construction procedures will work. The process of constructing and testing a test pad is usually a good learning experience for the contractor and CQC/CQA personnel; overall quality of a project is usually elevated as a result of building and testing the test pad.

A test pad is constructed with the soil liner materials proposed for a project utilizing preprocessing procedures, construction equipment, and construction practices that are proposed for the actual liner. If the required hydraulic conductivity is demonstrated for the test pad, it is assumed that the actual liner will have a similar hydraulic conductivity, provided the actual liner is built of similar materials and to standards that equal or exceed those used in building the test pad. If a test pad is constructed and hydraulic conductivity is verified on the test pad, a key goal of CQA/CQC for the actual liner is to verify that the actual liner is built of similar materials and to standards that equal or exceed those used in building the test pad.

2.2 Dimensions

Test pads normally measure about 10 to 15 m in width by 15 to 30 m in length. The width of the test pad is typically at least four times the width of the compaction equipment, and the length must be adequate for the compactor to reach normal operating speed in the test area. The thickness of a test pad is usually no less than the thickness of the soil liner proposed for a facility but may be as little as 0.6 to 0.9 m (2 to 3 feet) if thicker liners are to be employed at full scale. A freely draining material such as sand is often placed beneath the test pad to provide a known boundary condition in case infiltrating water from a surface hydraulic conductivity test (e.g., sealed double ring infiltrometer) reaches the base of the liner. The drainage layer may be drained with a pipe or other means. However, infiltrating water will not reach the drainage layer if the hydraulic conductivity is very low; the drainage pipe would only convey water if the hydraulic conductivity turns out to be very large. The sand drainage material may not provide adequate foundation support for the first lift of soil liner unless the sand is compacted sufficiently. Also, the first lift of soil liner material on the drainage layer is often viewed as a sacrificial lift and is only compacted nominally to avoid mixing clayey soil in with the drainage material.

2.3 Materials

The test pad is constructed of the same materials that are proposed for the actual project. Processing equipment and procedures should be identical, too. The same types of CQC/CQA tests that will be used for the soil liner are performed on the test pad materials. If more than one type of material will be used, one test pad should be constructed for each type of material.

2.4 Construction

It is recommended that test strips be built before constructing the test pad. Test strips allow for the detection of obvious problems and provide an opportunity to fine-tune soil specifications, equipment selection, and procedures so that problems are minimized and the probability of the required hydraulic conductivity being achieved in the test pad is maximized. Test strips are typically two lifts thick, one and a half to two equipment widths wide, and about 10 m (30 ft) long.

The test pad is built using the same loose lift thickness, type of compactor, weight of compactor, operating speed, and minimum number of passes that are proposed for the actual soil liner. It is important that the test pad not be built to standards that will exceed those used in building the actual liner. For example, if the test pad is subjected to 15 passes of the compactor, one would want the actual soil liner to be subjected to at least 15 passes as well. It is critical that CQA personnel document the construction practices that are employed in building the test pad. It is best if the same contractor builds the test pad and actual liner so that experience gained from the test pad process is not lost. The same applies to CQC and CQA personnel.

2.5 Protection

The test pad must be protected form desiccation, freezing, and erosion int he area where in-situ hydraulic conductivity testing is planned. The recommended procedure is to cover the test pad with a sheet of white or clear plastic and then either spread a thin layer of soil on the plastic if no rain is anticipated or, if rain may create an undesirably muddy surface, cover the plastic with hay or straw.

2.6 Tests and Observations

The same types of CQA tests that are planned for the actual liner are usually performed on the test pad. However, the frequency of testing is usually somewhat greater for the test pad. Material tests such as liquid limit, plastic limit, and percent fines are often performed at the rate of one per lift. Several water content-density tests are usually performed per lift on the compacted soil. A typical rate of testing would be one water content-density test for each 40 m^2 (400 ft^2). The CQA plan should describe the testing frequency for the test pad.

There is a danger in over testing the test pad -- excessive testing could lead to a greater degree of construction control in the test pad than in the actual liner. The purpose of the test pad is to verify that the materials and methods of construction proposed for a project can result in compliance with performance objectives concerning hydraulic conductivity. Too much control over the construction of the test pad runs counter to this objective.

2.7 In Situ Hydraulic Conductivity

2.7.1 Sealed Double-Ring Infiltrometer

The most common method of measuring in situ hydraulic conductivity on test pads is the sealed double-ring infiltrometer (SDRI). The test procedure is described in ASTM D-5093.

With this method, the quantity of water that flows into the test pad over a known period of time is measured. This flow rate, which is called the infiltration rate, which is called the infiltration rate (I), is computed as follows:

$$I = Q/At$$

where Q is the quantity of water entering the surface of the soil through a cross-sectional area A and over a period of time t.

Hydraulic conductivity (K) is computed from the infiltration rate and hydraulic gradient (i) as follows:

$$K = M1$$

Three procedures have been used to compute the hydraulic gradient. The procedures are called (1) apparent gradient method; (2) wetting front method; and (3) suction head method.

The apparent gradient method is the most conservative of the three methods because this method yields the lowest estimate of i and, therefore, the highest estimate of hydraulic conductivity. The apparent gradient method assumes that the test pad is fully soaked with water over the entire depth of the test pad. For relatively permeable test pads, the assumption of full soaking is reasonable, but for soil liners with K < 1 x 10-7 cm/s, the assumption of full soaking is excessively conservative and should not be used unless verified.

The second and most widely used method is the wetting front method. The wetting front is assumed to partly penetrate the test pad and the water pressure at the wetting front is conservatively assumed to equal atmospheric pressure. Tensiometers are used to monitor the depth of wetting of the soil over time, and the variation of water content with depth is determined at the end of the test. The wetting front method is conservative but in most cases not excessively so. The wetting front method is the method that is usually recommended.

The third method, called the suction head method, is the same as the wetting front method except that the water pressure at the wetting front is not assumed to be atmospheric pressure. The suction head (which is defined as the negative of the pressure head) at the wetting front is Hs and is added to the static head of water in the infiltration ring to calculate hydraulic gradient. The suction head Hs is identical to the wetting front suction head employed in analyzing water infiltration with the Green-Ampt theory. The suction head Hs is = the ambient suction head in the unsaturated soil and is generally very difficult to determine (Brakensiek, 1977). Two techniques available for determining Hs are:

1. Integration of the hydraulic conductivity function (Neuman, 1976):

$$Hs = Krd$$

where hSc is the suction head at the initial (presoaked) water content of the soil, Kr is the relative hydraulic conductivity (K at particular suction divided by the value of K at full saturation), and hs is suction.

2. Direct measurement with air entry permeameter (Daniel, 1989, and references therein).

Reimbold (1988) found that Hs was close to zero for two compacted soil liner materials. Because proper determination of Hs is very difficult, the suction head method cannot be recommended, unless the testing personnel take the time and make the effort to determine Hs properly and reliably.

Corrections may be made to account for various factors. For example, if the soil swells, some of the water that infiltrated into the soil was absorbed into the expanded soil. No consensus exists on various corrections and these should be evaluated case by case.

2.7.2 Two-Stage Borehole Test

The two-stage borehole hydraulic conductivity was developed by Boutwell (the test is sometimes called the Boutwell Test) and was under development as an ASTM standard at the time of this writing. The device is installed by drilling a hole (which is typically 100 to 150 mm in diameter), placing a casing in the hole, and sealing the annular space between the casing and borehole with grout. A series of falling head tests is performed and the hydraulic conductivity from

first stage (kl) is computed. Stage one is complete when kl ceases to change significantly. The maximum vertical hydraulic conductivity may be computed by assuming that the vertical hydraulic conductivity is equal to kl. However, the test may be continued for a second stage by removing the top of the casing and extending the hole below the casing. The casing is reassembled, the device is again filled with water, and falling head tests are performed to determine the hydraulic conductivity from stage two (k2). Both horizontal and vertical hydraulic conductivity may be computed from the values of kl and k2. Further details on methods of calculation are provided by Boutwell and Tsai (1992), although the reader is advised to refer to the ASTM standard when it becomes available.

The two-stage borehole test permeates a smaller volume of soil than the sealed double-ring infiltrometer. The required number of two-stage borehole tests for a test pad is a subject of current research. At the present time, it is recommended that at least five two-stage borehole tests are performed, then one would expect that all five of the measured vertical hydraulic conductivities would be less than or equal to the required maximum hydraulic conductivity for the soil liner.

2.7.3 Other Field Tests

Several other methods of in situ hydraulic conductivity testing are available for soil liners.

These methods include block samples, open infiltrometers, borehole tests with a constant water level in the borehole, porous probes, and air-entry permeameters. The methods are described by Daniel (1989) but are much less commonly used than the SDRI and two-stage borehole test.

2.7.4 Laboratory Tests

Laboratory hydraulic conductivity tests may be performed for two reasons:

1. If a very large sample of soil is taken from the field and permeated in the laboratory, the result may be representative of field-scale hydraulic conductivity. The question of how large the laboratory test specimen needs to be is currently a matter of research, but preliminary results indicate that a specimen with a diameter of approximately 300 mm (12 in.) may be sufficiently large (Benson et al., 1993).

2. If laboratory hydraulic conductivity tests are a required component of QA/QC for the actual liner, the same sampling and testing procedures are used for the test pad. Normally, undisturbed soil samples are obtained following the procedures outlined in ASTM D-1587, and soil test specimens with diameters of approximately 75 mm (3 in.) are permeated in flexible-wall permeameters in accordance with ASTM D-5084.

2.8 Documentation

A report should be prepared that describes all of the test results from the test pad. The test

pad documentation provides a basis for comparison between test pad results and the CQA data developed on an actual construction project.

2.9 Final Approval

Upon completion of the soil liner, the soil liner should be accepted and approved by the CQA engineer prior to deployment or construction of the next overlying layer.

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ASTM D-2487, "Classification of Soils for Engineering Purposes (Unified Soil Classification System)"

ASTM D-2488, "Description and Identification of Soils (Visual-Manual Procedure)"

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ASTM D-2937, "Density and Unit Weight of Soil In Place by Drive-Cylinder Method"

ASTM D-3017, "Water Content of Soil and Rock In Place by Nuclear Methods (Shallow Depth)"

ASTM D-4220, "Preserving and Transporting Soil Samples"

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ASTM D-4944, "Field Determination of Water (Moisture) Content of Soil by Calcium Carbide GasPressure Tester Method"

ASTM D-4959, "Determination of Water (Moisture) Content of Soil by Direct Heating Method"

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SECTION B-3.3

PROPOSED GROUNDWATER MONITORING PLAN OUTLINE FOR THE REMEDIATION WASTE STORAGE FACILITY

Revision 0
June, 1997

4.0 DESCRIPTION OF THE RWSF GROUNDWATER MONITORING PROGRAM

Introduction

The outline for the RWSF Groundwater Monitoring Plan is based on the current draft outline for the Rocky Flats Environmental Technology Site (RFETS) Integrated Monitoring Plan (IMP). It is intended that the RWSF specific groundwater monitoring requirements would be incorporated into the IMP once the groundwater monitoring requirements for the RWSF have been established during the design phase.

It is also intended that the current RFETS groundwater monitoring network be utilized to the greatest extent possible to satisfy background, upgradient, and downgradient monitoring requirements for the RWSF. This would be established through development of RWSF data quality objectives for groundwater monitoring during the design phase of the project.

The following attachments provide brief descriptions of the processes to be used to support development of a groundwater monitoring network for the RWSF.

Attachment 1. General Decision Criteria for Groundwater Monitoring Network Efficiency Analysis

Analysis of efficiency of existing monitoring wells and the evaluation of the need for additional wells will generally be based upon the following process:

1. Down gradient well placement

Step 1. Assess 50% Title II design
Step 2. Identify groundwater flow paths relative to facility placement within the CAMU
Step 3. Assess vertical component of groundwater flow.
Step 4. Assess seasonal and temporal factors affecting groundwater flow.
Step 5. Identify potential contaminant pathways.
Step 6. Determine spatial relationship to existing groundwater monitoring network.
Step 7. Select additional monitor well sites as appropriate.

2. Up gradient well placement.

Step 1. Assess 50% Title II design
Step 2. Identify groundwater flow paths up gradient relative to facility placement within the CAMU
Step 3. Assess seasonal and temporal factors affecting groundwater flow.
Step 4. Assess historical data for area surrounding the CAMU.
Step 5. Determine spatial relationship to existing groundwater monitoring network.
Step 6. Determine data adequacy of existing data and upgradient wells.
Step 7. Select additional monitor well sites as appropriate.

Attachment 2. Release Reporting Assessment Criteria

Problem Statement:
The problem statement for RCRA Monitoring wells is: Have concentrations in downgradient monitoring wells exceeded mean concentrations in upgradient monitoring wells at RCRA units?

Problem Scope:
RCRA monitoring is conducted to detect potential excursions of contamination below the point of compliance established for RCRA units on Site. RCRA units are considered to be any units that are regulated under 6 CCR 1007-2 solid waste requirements, such as the Present Landfill and the New Sanitary Landfill, and any future waste repositories.

Decision Statement:

IF	Mean concentrations in any downgradient wells exceed the mean concentration in upgradient wells
AND	Concentrations at that well show an upward trend with time
THEN	Report to appropriate agencies and initiate investigation into possible causes
ELSE	Continue Monitoring

Inputs:

- Unit Specific PCOCs
- Field Parameters
- Water Levels

Boundaries:

Spatial: Decisions are based on pooled results of upgradient wells and on a well head basis in downgradient wells.

Temporal: Data will be reviewed quarterly and decisions will be made on an annual basis

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SECTION B-3.4

CONSTRUCTION QUALITY ASSURANCE PLAN OUTLINE FOR THE REMEDIATION WASTE STORAGE FACILITY

Revision 0
June, 1997

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13.0 PIPING - PLASTIC

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22.0 INSTRUMENTATION

CONTROL OF CONSTRUCTION QUALITY ASSURANCE PLAN

The Construction Quality Assurance Plan (CQAP) document is for the use of all Quality Assurance and Quality Control staff, Project Engineers, Construction engineers, and all construction subcontractors site personnel involved with the construction of the Remediation Waste Storage Facility (RWSF) project at the Rocky Flats Environmental Technology Site. The Corporate Quality Assurance Manager will maintain a record of the recipients of the manual.

Controlled copies of this manual will be issued to appropriate project personnel involved in the supervision of work performed to the requirements of this manual.

From time to time, it may become necessary to prepare revisions to this manual. When a revision is prepared, the change shall be noted by a vertical line in the left-hand margin. If a revision is made to the same sheet, the line indicating a previous change will be removed. Revisions shall be distributed with a new index showing the effective revision of the applicable section. When a complete re-write of the CQAP is issued, no margin lines will be used. Revisions will receive a review and approval equivalent to the original.

When it becomes necessary to define project-specific activities and/or delete those activities which are not applicable to that project, an Addendum to this manual, it is understood that reference to a specific individual will include the individual's designee, provided they are in the same department and are qualified to perform the designated function. In all cases, the quality requirements shall be verified and documented by persons not directly performing the work, and responsibility for the work remains with the designated individual.

1.1 PURPOSE OF PLAN

This Construction Quality Assurance Plan (CQAP) establishes the construction quality assurance program, supervision, inspection and testing of all items of work, including those of suppliers and Subcontractors, which will demonstrate compliance with subcontract documents, applicable standards, and permitting requirements related to the construction activities for the Rocky Flats RWSF at the Department of Energy's Rocky Flats Environmental Technology Site (RFETS), Golden Colorado. Implementation of the CQAP will help to provide quality work, cost and schedule control, and regulatory compliance.

The CQAP has been developed as one document. Within this document there are three main parts. The first part is the general section covering the project as a whole. In Part 2, the plan was developed to meet the needs for the waste cell, liner installation, and leachate collection/detection system construction. This is included as the plan covering the RWSF construction. The third part of the CQAP, will focus on the remainder of the RWSF facility, such as the building construction, mechanical systems, electrical and instrumentation system, and general civil-oriented site development.

The reasoning behind the development of these three separate parts for the project Construction Quality Assurance Plan development was the need to segregate the two basic building sections into separate parts of the CQAP. The waste cell construction design is expected to be submitted for review by the Jefferson County Planning and Health Departments, and the Hazardous Materials and Waste Management Division of the Colorado Department of the Public Health and Environment (CDPHE).

The CQA Plan, of the Title II Design Package contains QA information for the complete construction of the RWSF. Construction quality assurance requirements for the following items are contained in the Part 2 - Waste Cell and Liner Systems Construction portion of the CQAP document:

- Geomembrane Liners,
- Geosynthetic Drainage Layers,
- Leachate Detection/Collection Systems,
- Low Permeability Clay Liners,
- Cover Systems,
- Internal Berms,
- Reinforced Concrete, and
- Subgrade Preparation.

In Part 3 of the CQAP, the remainder of the facility quality assurance requirements are identified. In this Part, the sections of the CQAP are focussed on the standard construction industry practices for the types of construction associated with the general site development, the building and mechanical systems, electrical power distribution and various other systems as shown on the Construction Drawings and Specifications for the complete RWSF.

Construction quality assurance for the following components are contained in the Part 3 of the CQAP portion of the project. This portion of the total project quality assurance for the project is designated to cover:

- Earthwork for general site grading and structural foundation;
- Underground and overhead utilities (water, electrical, instrumentation, etc.);
- Building structural and mechanical systems;
- Equipment decontamination facilities;
- Personnel decontamination facilities; and
- Roadway and storm drainage components.

These two parts of the CQAP make up the full QA requirements for the construction of the RWSF at the Rocky Flats Environmental Technology Site. The Construction Subcontractor, along with the Contractor and Contractor's representatives shall be knowledgeable of all requirements for the Project QA procedures.

The elements contained within all parts of this CQAP include:

(1) Defining responsibility and authority of all organizations and key personnel,

(2) Qualifications of CQA personnel,

(3) Summary of the activities used to document the installation,

(4) Presenting sampling requirements for key components, and

(5) Description of the documentation to be completed and archived.

1.2 PLAN USERS

The Quality Assurance and Quality Control staff, project engineers, construction engineers, and all Construction Subcontractor site engineers, managers, and foreman are required to become familiar with all parts of this document. All parties are required to review this document with particular attention to those sections applicable to their responsibilities.

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SECTION B-3.5

HEALTH AND SAFETY PLAN OUTLINE FOR THE REMEDIATION WASTE STORAGE FACILITY

Revision 0
June, 1997

The outline below has been prepared to describe the general content of the Health and Safety Plan for the Remediation Waste Storage Facility (RWSF). During or after design, the outline should be reviewed for applicability and revised as necessary.

1.0 INTRODUCTION

1.1 Purpose and Scope

1.2 Implementation and Modification of the Site Safety and Health Plan

1.3 Organization

2.0 SITE AND RWSF FACILITY INFORMATION

2.1 General Site Description

2.1.1 Site Status
2.1.2 Site History
2.1.3 Climate
2.1.4 Locations of Resources Available to Onsite Personnel

2.2 Potential Chemicals Detected in Wastes Received at the Facility

2.3 Site Zones

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2.3.2 Contamination Reduction Zones
2.3.3 Exclusion Zones

2.4 Site Control

3.0 PROJECT ORGANIZATION AND PERSONNEL REQUIREMENTS

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4.0 HEALTH AND SAFETY PROGRAMS

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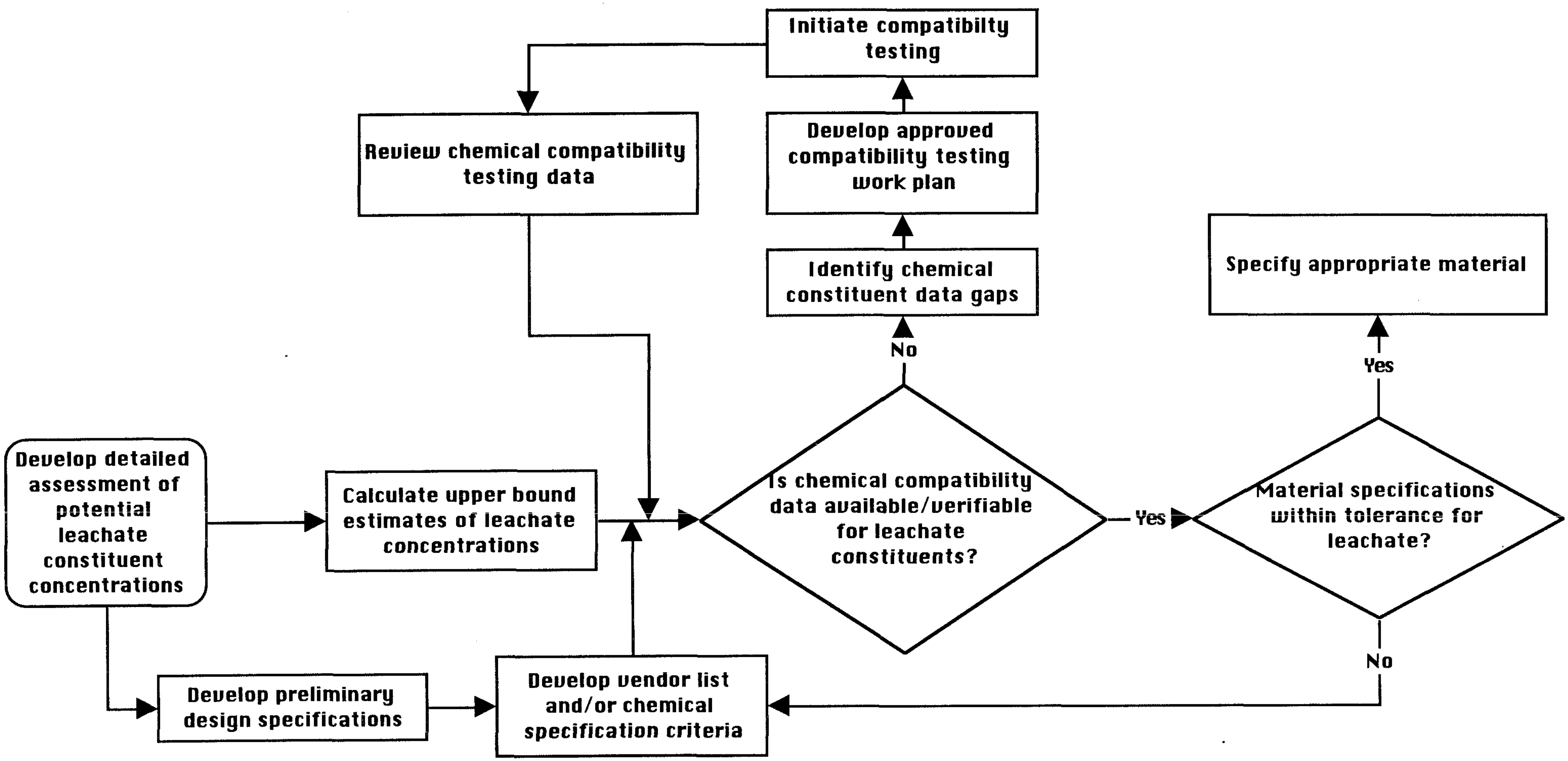
SECTION B-3.6

CHEMICAL COMPATIBILITY TESTING DECISION PROCESS

Revision 0
June, 1997

Chemical Compatibility
Testing Decision Process



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SECTION B-3.7

ACTION LEAKAGE RATE AND RESPONSE ACTION PLAN OUTLINE FOR THE REMEDIATION WASTE STORAGE FACILITY

Revision 0
June, 1997

The outline below has been prepared to describe the general content of the Remediation Waste Storage Facility Action Leakage Rate and Response Action Plan. During or after design, the outline should be reviewed for applicability and revised as necessary.

1.0 INTRODUCTION

1.1 Purpose and Scope

1.2 Organization

2.0 ACTION LEAKAGE RATE

2.1 Background
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2.2 Action Leakage Rate Calculation

2.3 Operational Leakage Rate Calculation

2.4 Action Leakage Rate Excedance

3.0 RESPONSE ACTION PLAN

3.1 Initial Notification

3.2 Source Assessment

3.3 Response Actions

3.4 Status Notifications

4.0 ACRONYMS

5.0 REFERENCES

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SECTION B-3.8

CONTINGENCY PLAN OUTLINE FOR THE REMEDIATION WASTE STORAGE FACILITY

Revision 0
June, 1997

The outline below has been prepared to describe the general content of the Remediation Waste Storage Facility Contingency Plan. During or after design, the outline should be reviewed for applicability and revised as necessary.

1.0 INTRODUCTION

1.1 Purpose and Scope

1.2 Organization

2.0 EMERGENCY COORDINATORS

3.0 IMPLEMENTATION OF THE CONTINGENCY PLAN

3.1 RWSF Modules

3.1.1 Containment Failure or Failure Due to External Forces
3.1.2 Human Exposure
3.1.3 Reportable Quantities

3.2 Decontamination Facilities

3.2.1 Containment Failure or Failure Due to External Forces
3.2.2 Human Exposure
3.2.3 Reportable Quantities

3.3 Waste Staging/Consolidation Areas

3.3.1 Containment Failure or Failure Due to External Forces
3.3.2 Human Exposure
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4.2 Incident Phase

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4.2.2 Identification and Compatibility of Hazardous Wastes
4.2.3 Wind Rose
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SECTION B-3.9

INSPECTION PLAN OUTLINE FOR THE REMEDIATION WASTE STORAGE FACILITY

Revision 0
June, 1997

The outline below has been prepared to describe the general content of the Inspection Plan for the Remediation Waste Storage Facility. During or after design, the outline should be reviewed for applicability and revised as necessary.

1.0 INTRODUCTION

1.1 Purpose and Scope

1.2 Organization

2.0 INSPECTION REQUIREMENTS

2.1 RWSF Modules

2.2 Leachate Detection and Collection Systems

2.3 Run-on/Runoff Control Systems

2.4 Decontamination Facilities

2.5 Waste Staging/Consolidation Areas

2.6 Emergency Response Systems

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4.0 DEFICIENCY CORRECTION REQUIREMENTS

5.0 RECORDKEEPING REQUIREMENTS

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SECTION B-3.10

OPERATING RECORD SYSTEM PLAN OUTLINE FOR THE REMEDIATION WASTE STORAGE FACILITY

Revision 0
June, 1997

The outline below has been prepared to describe the general content of the Operating Record System Plan. During or after design, the outline should be reviewed for applicability and revised as necessary.

1.0 INTRODUCTION

1.1 Purpose and Scope

1.2 Organization

2.0 WASTE DESCRIPTION, QUANTITIES, AND DISPOSITION

3.0 WASTE ANALYSES

4.0 CONTINGENCY PLAN IMPLEMENTATIONS

5.0 INSPECTION RECORDS

6.0 MONITORING, TESTING, AND ANALYTICAL DATA

7.0 RECORDS OF CORRECTIVE ACTION

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9.0 RECORD RETENTION, AVAILABILITY, AND DISPOSITION

10.0 BIENNIAL REPORTING REQUIREMENTS

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SECTION B-3.11

PERSONNEL TRAINING PLAN OUTLINE FOR THE REMEDIATION WASTE STORAGE FACILITY

Revision 0
June, 1997

The outline below has been prepared to describe the general content of the Personnel Training Plan for the Remediation Waste Storage Facility. During or after design, the outline should be reviewed for applicability and revised as necessary.

1.0 INTRODUCTION

1.1 Purpose and Scope

1.2 Organization

2.0 GENERAL

2.1 Instructor Qualifications

2.2 Training Schedule
- 2.2.1 On-the-Job Training
- 2.2.2 Classroom Training

3.0 CURRICULUM

3.1 Emergency Response
- 3.1.1 Spill Response
- 3.1.2 Fires and Explosions
- 3.1.3 Natural Forces
- 3.1.4 Other Emergencies
- 3.1.5 Emergency Shutdown Procedures

3.2 Emergency Equipment

3.3 Alarm and Communication Systems

3.4 Waste Management

4.0 RECORDKEEPING

4.1 Job Descriptions

4.2 Training Descriptions

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SECTION B-3.12

SECURITY PLAN OUTLINE FOR THE REMEDIATION WASTE STORAGE FACILITY

Revision 0
June, 1997

1.0 PURPOSE

1.1 Activity Overview

The plan will cover the operations of the Remediation Waste Storage Facility (RWSF). Operations include but are not limited to :

- The handling and placement of remediation wastes within the facility;
- Associated maintenance activities;
- Required inspections;
- Waste staging and shipment;
- Health and safety monitoring and oversight;
- Additional required monitoring;
- Facility access control; and
- Leachate collection and treatment activities

1.2 Security Plan Objective

This plan prescribes security measures to protect human health and the environment from wastes stored within the facility and any classified matter received, used, and stored by employees.

2.0 SCOPE

2.1 Activity Description and Management Organization

This plan addresses any required security measures required while work is performed or the facility remains in operation.

- Construction Manager;
- Operations Manager;
- Facility Security Officer (FSO); and
  Operations personnel.

2.2 Target Description

This plan describes the security measures implemented to ensure the protection of human health and the environment from any release or threat of release of remediation wastes from the RWSF. This program protects classified matter and unclassified but sensitive matter used to direct work that may be used or is applicable to personnel at the RWSF.

2.3 Threat Description

2.4 Limitations

3.0 RESPONSIBILITIES

3.1 All Employees

All employees have the responsibility to:

- Follow all operational , health and safety, and other applicable work control procedures.
- Identify issues of concern relating to violation of procedure or any other potential health and safety, operational, or security concern.
- Comply with all RFETS Safeguards and Security Program requirements including those stated in the RWSF Security Plan.

3.2 Operations Manager

3.3 Contractor Technical Representative, Kaiser-Hill

3.4 Facility Security Officer

3.5 Security Custodian

4.0 SAFEGUARDS AND SECURITY PROGRAM REQUIREMENTS

The target identified by this plan and all other items of Department of Energy, Rocky Flats Environmental Technology Site safeguards and security interest are protected by an integrated system of safeguards and security program activities applied with a graded approach.

4.1 Physical Protection Program

The physical protection program is directed by DOE-5632.1C, Protection and Control of Safeguards and Security Interests.

4.2 Protection Force Program

The program is directed by DOE-5632.7A, Protective Forces.

4.3 Nuclear Material Control Program

4.4 Personnel Security Program

The program is directed by DOE-5631.2C, Personnel Security Program.

4.5 Information Security Programs

4.5.1 Classified Matter Protection & Control (CMPC)

The CMPC program is directed by DOE-5639.1, information Security Program.

4.5.2 Classified Automated Information Systems (AIS) Security Program

The classified AIS program is directed by DOE-5639.6A, Classified Automated Information Security Program.

4.5.3 Operations Security (OPSEC) Program

The OPSEC program is directed by DOE-5639.7, Operations Security Program. Additional direction is provided by the DOE-OPSEC Master Plan, RFFO Instruction 5639.7, and the Kaiser-Hill Implementation Plan.

4.5.4 Counterintelligence (CI) Program

The CI program is directed by DOE-5670.3, Counterintelligence Program.

4.5.5 Technical Surveillance Countermeasures (TSCM) Program

The TSCM program is directed by DOE-5639.5, Technical Surveillance Countermeasures Program.

4.5.6 Violations of Law, Losses, and Incidents of Security Concerns (VOLLI) Program

The program is directed by DOE-5639.3, Violations of Law, Losses, and Incidents of Security Concerns.

4.6 Security Awareness Program

The program is directed by DOE-5631.1C, Safeguards and Security

Awareness Program.

4.7 Physical Protection of DOE Property and Unclassified Facilities

Program direction is included in DOE-5632.1C, Protection and Control of Safeguards and Security Interests.

4.8 Safeguards and Security Evaluation Program

Employees, facilities, and procedures are subject to audit to evaluate compliance with the requirements stated in this security plan.

4.9 Security Plan Review Process

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SECTION B-3.13

PRELIMINARY WASTE ACCEPTANCE CRITERIA FOR ACCEPTANCE OF WASTE AT THE REMEDIATION WASTE STORAGE FACILITY

Revision 0
June, 1997

Table of Contents

1.0 PURPOSE

This document specifies waste acceptance criteria (WAC) for wastes to be stored of at the Remediation Waste Storage Facility (RWSF) Corrective Action Management Unit (CAMU). These criteria were established by the Environmental Protection Agency (EPA), Colorado Department of Public Health and Environment (CDPHE), Department of Energy (DOE), and Department of Transportation (DOT). Compliance with the WAC ensures that storage of wastes meets all applicable requirements. Using the WAC ensures the following goals are achieved:

a. Hazardous and radioactive remediation wastes are effectively isolated from potential natural environmental pathways to protect the public health and environment,

b. Only specified wastes are accepted for storage,

c. Compliance by RWSF operating personnel and generators to requirements,

d. Characteristics of the disposed wastes are known, certified, and available.

The central purpose for a CAMU designation is to allow safe and protective storage of hazardous and radioactive remediation wastes without treatment to meet Land Disposal Restrictions criteria. A CAMU is established to facilitate the implementation of reliable, effective, protective, and cost-effective remedies by providing an appropriate location for storage of hazardous and radioactive remediation wastes to facilitate offsite disposal. As such, certification of stored wastes will normally be via analytical data from the specific remediation projects. A sampling and analysis plan can be used if analytical data is not sufficient to certify the waste.

2.0 SCOPE

This document applies to all Rocky Flats Environmental Technology Site (RFETS) contractors, subcontractors, and Department of Energy, Rocky Flats Field Office (DOE,RFFO) remediation waste generators.

The RWSF will only accept wastes meeting the definition of remediation wastes; typically wastes derived from environmental remediation (ER) cleanup and decontamination and decommissioning (D&D) activities at the RFETS.

Treatment of wastes, including size reduction, to meet storage criteria will be the responsibility of the waste generator and will not be done at the RWSF.

Waste acceptance will be based upon compliance with the waste acceptance criteria and waste analysis requirements to be defined during the design phase. Sampling procedures, analytical procedures, and quality assurance requirements will be consistent with the current RFETS sampling, analysis, and quality assurance programs and procedures and will be identified in the Waste Acceptance Criteria document.

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ABBREVIATIONS AND ACRONYMS

Am	americium
CAMU	Corrective Action Management Unit
CCR	Code of Colorado Regulations
CDPHE	Colorado Department of Public Health and Environment
CHWA	Colorado Hazardous Waste Act
cm/sec	centimeters per second
cy	cubic yards
D&D	deactivation and decontamination
DOE	United States Department of Energy
ESF	East Spray Fields (IHSS 216.2 and 216.3)
FY	fiscal year
HW	hazardous waste
IA	Industrial Area
IA-East	Industrial Area-East
IA-West	Industrial Area-West
IDM	Investigation-Derived Material
IHSS	Individual Hazardous Substance Site
IM/IRA	Interim Measure/Interim Remedial Action
ITS	Interceptor Trench System
NEPA	National Environmental Policy Act
NSL	New Sanitary Landfill
PA	Protected Area
PAC	potential areas of concern
PCB	polychlorinated biphenyls
Pu	plutonium
RCRA	Resource Conservation and Recovery Act
RFCA	Rocky Flats Cleanup Agreement
RWSF	Remediation Waste Storage Facility
SME	Subject Matter Expert
SE Quad	Southeast Quadrant
Site	Rocky Flats Environmental Technology Site
Site Vision	Rocky Flats Conceptual Vision
SW Quad	Southwest Quadrant
TSCA	Toxic Substance Control Act

EXECUTIVE SUMMARY

A Remediation Waste Storage facility (RWSF) has been envisioned to store remediation waste at the Rocky Flats Environmental Technology Site (Site). The objectives of this siting study are to identify and rank criteria to be used to select a location, develop a methodology for comparative analysis of different locations, and select location(s) that would be suitable for a RWSF within the boundaries of the Site, using the identified criteria and methodology for comparative analysis.

The location would be for a RWSF that accepts remediation wastes with low-level radioactive and/or hazardous constituents but would not preclude the shipment of remediation waste that could be more effectively and economically managed offsite. The facility would be designed and constructed to meet all of the applicable federal, state, and local regulatory requirements.

Seven onsite locations were identified and carried through the location selection process. The three locations in the Industrial Area (IA) are the IA-West, IA-East, and the area adjacent and to the east of the Solar Ponds. The four locations in the buffer zone are the New Sanitary Landfill (NSL), the East Spray Fields (ESF), the Southeast Quadrant (SE Quad), and the Southwest Quadrant (SW Quad).

Six categories were considered in developing the comparative analysis. These criteria include regulatory requirements and guidelines that have been discussed during various stakeholder meetings regarding a RWSF at the Site. These criteria have been placed into six general categories, and further divided into 35 specific subdivisions.

The following general criteria categories were assigned a weighting factor (%) totaling 100%:

Category 1, Corrective Action Management Unit (CAMU) Criteria - 20%

Category 2, Public Protection (Geotechnical and Hydrological Criteria) - 20%

Category 3, Site Special Issues - 15%

Category 4, Cost Criteria - 15%

Category 5, Regulatory Support - 15%

Category 6, Other Stakeholder Concerns - 15%

The following locations were evaluated against the criteria and given an overall ranking between 0 and 100%, with 100% being the most favorable location for the siting of a RWSF.

Solar Ponds location, IA	68.3%
IA-West location, IA	67.6%
New Sanitary Landfill, buffer zone	67.4%
SE Quad location, buffer zone	66.4%
ESF location, buffer zone	66.1%
SW Quad location, buffer zone	63.4%
IA-East location, IA	62.5%

Overall, the Solar Ponds location was ranked slightly higher than the IA-West location and the NSL as a place to locate a RWSF at the Site. The results of this study are detailed and summarized herein.

Category 1, CAMU, favored the IA locations, with the designation of the location as a CAMU. The ability to reduce the areal extent of contamination without contaminating clean areas weighed heavily in favor of the IA locations.

Category 2, Public Protection, ranked three of the buffer zone locations the highest. The primary concern with the locations in the IA is the elevated groundwater table. This concern is somewhat mitigated, however, by the fact that all viable design alternatives envisioned are above-grade facilities.

Category 3, Site Special Issues, ranked the SE Quad location the highest, followed by the Solar Ponds, and ESF location. The three locations in the IA all received high ranking for the ability to support the Rocky Flats Conceptual Vision (Site Vision) in terms of future land use. Nevertheless, the existing infrastructures lowered the overall scores in this category. There are extensive underground and overhead utilities encountered within most of the IA, as well as other building and waste storage facilities, that would have to be removed or re-routed.

Category 4, Cost Criteria, favored the buffer zone locations. The main consideration of the locations within the IA is the cost associated with removing, re-routing, or replacing building and underground and overhead utilities in the IA. An additional consideration to The Solar Pond location is the burden of constructing a portal through the Protected Area (PA) security fence, constructing a fence surrounding the location, and providing a security staff during construction and operation of the facility.

Category 5, Regulatory Support, showed support clearly in favor of a location in the IA. The Solar Ponds location was ranked highest followed by IA-East and IA-West.

Category 6, Other Concerns, ranked the IA locations the highest. The general public would probably be receptive to placing environmental waste in areas that already contain some contamination rather than siting a RWSF in an area that has no history of contamination. Also, the Jefferson County, Colorado Board of Commissioners stated their desire to maintain the buffer zone around the IA as undeveloped open space (Resolution No. CC94-654).

C.1 OBJECTIVES

For this project, the reduction of environmental risk is dependent on the ability to disposition and manage remediation waste. As part of risk reduction at the Rocky Flats Environmental Technology Site (the Site), it is currently projected that there is 100,000 to 300,000 cubic yards [cy] of remediation waste to be excavated and appropriately managed. See Table 3-1 Waste Identification and Volumes for a Remediation Waste Storage Facility, in the IM/IRA Decision Document for the RWSF for a break down of volumes by source and waste type. This waste will come from soils excavated from Individual Hazardous Substance Sites (IHSSs), accelerated actions, D&D waste and investigative derived waste (IDM). This waste consists of media with hazardous constituents or with mixed hazardous/low-level radioactive constituents. The waste streams will include, but are not limited to (approximate percentage of waste is in parentheses):

- Debris from decontamination and decommissioning activities
- Contaminated soil and debris collected from accelerated actions and hot spots removals
- Pond sludge
- Asphaltic materials and pondcrete
- Investigation-Derived Material (IDM) from characterization (not suitable for disposal in the sanitary landfill) and intrusive investigation activities
- Toxic Substance Control Act (TSCA) waste such as asbestos and polychlorinated biphenyls (PCBs)
- Treatment by-products from groundwater, surface water, and/or soil remediation actions

To store this remediation waste, a RWSF has been proposed to be located within the boundaries of the Site. This task was undertaken to identify the optimal location for the facility. The three objectives of this task are to:

1. Identify and rank criteria to be used for location selection.
2. Develop a methodology for comparative analysis of different locations.

3. Select a suitable location for construction of a facility with the capacity to accommodate 100,000 to 300,000 cy of environmental waste (using the identified criteria and methodology for comparative analysis).

C.2 COMPARATIVE ANALYSIS OF SITE LOCATIONS (ALTERNATIVES)

C.2.1 SCREENING CRITERIA DEFINED

The location must accommodate a facility that would accept (for storage) remediation waste with low-level radioactive and/or hazardous constituents. The facility would be designed and constructed to substantively comply with all applicable federal, state, and local regulatory requirements.

A number of categories were considered in developing the location criteria matrix. The criteria included requirements and guidelines that have been discussed during various stakeholder meetings regarding RWSF at the Site. These criteria can be placed into six major categories: (1*) Corrective Action Management Unit (CAMU) Criteria*, adherence to the key points of this category is fundamental if the RWSF is to designated a CAMU, (2) *Public Protection*, this geological and geotechnical criteria is a reasonable basis for judging the protectiveness of the alternatives, (3) *Site Special Issues*, these are issues that are unique to RFETS that require consideration in the selection of a location for a RWSF, (4*) Cost Criteria*, (5) *Regulatory Support*, and (6) *Other Stakeholder Concerns* which generally deals with community acceptance. Each of these categories is further divided into specific issues. These categories and specific issues are discussed in the following subsections.

C.2.1.1 Category 1: Corrective Action Management Unit (CAMU) Criteria

Category 1, CAMU, focuses on the designation of the RWSF as a CAMU, per 6 CCR 1007-3, 264.522 (c), and is a critical factor in locating the facility at the Site, with the following key points:

1. The CAMU shall facilitate the implementation of reliable, effective, protective, and cost-effective remedies.

2. Waste management activities associated with the CAMU shall not create unacceptable risks to humans or the environment resulting from exposures to hazardous waste or hazardous constituents.

3. The CAMU shall include uncontaminated areas of the facility only if the inclusion of such areas for the purpose of managing remediation waste is more protective than management of wastes at contaminated areas of the facility.

4. Areas within the CAMU where remediation wastes remain in place after closure of the CAMU

shall be managed and contained to control, minimize, or eliminate future releases to the extent necessary to protect human health and the environment. (The above key point of the CAMU regulation is not applicable to this siting study because there will be no waste left in place.)

5. The CAMU shall expedite the timing of remedial activity implementation, unless to do so would be inconsistent with 6 CCR 1007-3, 264.552(c)(1) or (c)(2).

6. The CAMU shall minimize the land area of the facility upon which remediation wastes will remain in place after closure of the CAMU, unless to do so would be inconsistent with 6 CCR 1007-3, 264.522 (c)(1) or (c)(2). (The above key point of the CAMU regulation is not applicable to this siting study because there will be no waste left in place.)

7. The CAMU shall enable the use, when appropriate, of treatment technologies, including innovative technologies, to enhance the long-term effectiveness of remedial actions by reducing the toxicity, mobility, or volume of remedial waste.

C.2.1.2 Category 2: Public Protection (Geotechnical and Hydrological Criteria)

Category 2, Public Protection, consists of geological, geotechnical and hydrological considerations to ensure the protection of the public. These considerations are summarized below:

1. The geological and hydrogeologic conditions of a location in which hazardous waste is to be stored should be such that reasonable assurance is provided that the wastes are isolated within the storage area away from pathways to the public.

2. Geomorphic conditions either will not vary significantly from the present state or will occur to a predictable degree, which can be accommodated in the facility design.

3. Structural-related issues include slope and geotechnical stability.

4. The immediate area of the location should be in strata of minimal groundwater flow.

5. Geological strata combined with engineering barriers shall provide minimum permeability.

6. Siting consideration should include bedrock and surface integration including the nature and extent of bedrock material.

7. Siting consideration should include minimal relative presence of fractures or faults.

8. Consideration should be given to the relative depth to bedrock and groundwater, including seasonal fluctuations for groundwater.

9. The Site will not impact nor be impacted by surface water.

10. Relative distance to nearest discharge area shall include consideration of groundwater flow direction and travel time.

11. The terrain is such that good drainage exists for movement of precipitation away from the storage area, and such that water and wind erosion will be minimal.

C.2.1.3 Category 3: Site Special Issues

Category 3, Site Special Issues, supports the timely construction of a facility and integration with other Site programs, including the Site Vision to occur, and includes:

1. Ability of the site to support the Site Vision and RFCA objectives.

2. Impacts from existing utility, sewer, process waste, or communications lines

3. Impacts from security

4. Impacts from plutonium (Pu) consolidation or residue stabilization activities

5. Impacts from decommissioning activities

6. Impacts from current RCRA units

7. Impacts from mineral rights issues or other easements

8. Ability to collocate additional RWSFs in the same vicinity

C.2.1.4 Category 4: Cost Criteria

Category 4, Cost Criteria, presents cost considerations assigned as two separate criteria:

1. Cost of engineering and construction of protective measures

2. Cost of location preparation including building demolition, subsurface utility line removal and rerouting, access requirements, and power/facility requirements above the basic RWSF

C.2.1.5 Category 5: Regulatory Support

Category 5, Regulatory Support, focuses on using the State principles for onsite waste management of contaminated materials, per the February 27, 1995 letter from Tom Looby (CDPHE) to Jack McGraw (EPA) and Mark Silverman (DOE). The following principles have been evaluated in this study to ensure consistency with EPA and CDHPE desires, but because the RWSF being proposed is for storage, not disposal, some of these criteria may not be appropriate for siting a storage facility.

1. The number of disposal locations must be minimized. "We (CDPHE) suggest one centralized location be chosen for consolidation of contaminated materials."

2. "Every effort should be made to locate a centralized disposal facility in an area of optimal geologic parameters preferably within or close to the Industrial Area (IA)."

3. "Any disposal facility must be designed and built as a state-of-the-art disposal facility that meets or exceeds all permitting and regulatory requirements. This includes (but not limited to) siting, design, long-term protection, and performance requirements."

4. "A permitted centralized disposal facility provides DOE the greatest degree of future applicability and utility. As such, we believe that a centralized disposal facility should be designed with the intent to permit it from a RCRA/CHWA perspective."

5. "Any disposal location at RFETS should be located in areas that have limited future land use potential and will be controlled by DOE until the interred waste no longer presents a risk to human health or the environment."

C.2.1.6 Category 6: Other Stakeholder Concerns

Category 6, Other Stakeholder Concerns, lists the following stakeholder concerns that have been factored into the analysis:

1. General public perception and acceptance

2. Municipal or County acceptance

3. Department of Energy (DOE) Orders

4. National Environmental Policy Act (NEPA)

C.2.2 METHODOLOGY

A weighting system (modified from Dawson, G. W. and Mercer, B.W., Hazardous Waste Management, 1986) was used to develop the ranking system.

First, a subjective weighting factor (%) was assigned to each of the six general categories of criteria, totaling 100%, as shown in Table C-1, Criteria Comparison.

Table C-1 Criteria Comparison

Category	Criteria	Weighting Factor (%)
1	Corrective Action Management Unit (CAMU) Criteria	20
2	Public Protection (Geotechnical and Hydrological Criteria)	20
3	Site Special Issues	15
4	Cost Criteria	15
5	Regulatory Support	15
6	Other Stakeholder Concerns	15
	Total	**100**

Second, each of the six general categories was divided into specific issues as shown in Table C-2, RWSF Location Criteria Detail, and each specific issue was subjectively assigned a value between 1 and 3, with 3 being more important criteria, and 1 being less important criteria.

Third, each of the locations (e.g., Industrial Area-West [IA-West] and Industrial Area-East [IA-East]) was compared to the specific issue, as well as the relativity to one another, and a calculated value between 0 and 1 was determined; 1 would be very favorable, and a value of 0 would indicate a fatal flaw resulting in removing that location from further consideration for a RWSF, as shown in Table C-2.

This matrix form was developed showing location versus specific issues, as shown in Table C-2. This form was distributed to Subject Matter Experts (SMEs) for scoring. The scores were averaged, and average values were used to complete the ranking. If there was a major difference between SMEs, discussions were held to resolve those differences.

SITING CRITERIA				Alternative Sites													
				Industrial Area						Buffer Zone							
				IA - West		IA - East		Solar Ponds		NSL		ESF		SE Quad		SW Quad	
		Weight %	Total Available Points	Points Scored	multi factor 0-1	Points Scored	multi factor 0-1	Points Scored	multi factor 0-1	Points Scored	multi factor 0-1	Points Scored	multi factor 0-1	Points Scored	multi factor 0-1	Points Scored	multi factor 0-1
	Category 1, CAMU Criteria - Ability to designate as CAMU. Per 6 CCR 1007-3 264.552 (c)	20															
1	The CAMU shall facilitate the implementation of reliable, effective, protective, and cost effective remedies.		3	1.8	0.6	1.5	0.5	2.1	0.7	3.0	1	2.7	0.9	2.7	0.9	2.7	0.9
2	Waste management activities associated with the CAMU shall not create unacceptable risks to humans or to the environment resulting from exposures to hazardous waste or hazardous constituents.		3	2.4	0.8	2.4	0.8	2.4	0.8	2.1	0.7	2.1	0.7	2.1	0.7	2.1	0.7
3	The CAMU shall include uncontaminated areas of the facility, only if including such areas for the purposes of managing remediation waste is more protective than management of such wastes at contaminated areas of the facility.		2	1.4	0.7	1.4	0.7	1.6	0.8	1.2	0.6	1.2	0.6	1.2	0.6	1.2	0.6
4	The CAMU shall expedite the timing of remedial activity implementation, unless to do so would be inconsistent with 264.552 (c)(1) or (c)(2).		3	2.4	0.8	2.4	0.8	2.4	0.8	2.4	0.8	2.4	0.8	2.4	0.8	2.4	0.8
5	The CAMU shall enable the use, when appropriate, of treatment technologies to enhance long term effectiveness of remedial actions by reducing the toxicity, mobility or volume of remedial waste.		2	1.8	0.9	1.8	0.9	1.8	0.9	1.8	0.9	1.8	0.9	1.8	0.9	1.8	0.9
CAMU Criteria			13.0	9.8		9.5		10.3		10.5		10.2		10.2		10.2	

SITING CRITERIA				Alternative Sites													
				Industrial Area						Buffer Zone							
				IA - West		IA - East		Solar Ponds		NSL		ESF		SE Quad		SW Quad	
		Weight %	Total Available Points	Points Scored	multi factor 0-1	Points Scored	multi factor 0-1	Points Scored	multi factor 0-1	Points Scored	multi factor 0-1	Points Scored	multi factor 0-1	Points Scored	multi factor 0-1	Points Scored	multi factor 0-1
	Category 2, Public Protection - Geological, Geotechnical and Hydrological Criteria	20															
1	The geological and hydrological conditions of a site in which HW are to be stored should be such that there is reasonable assurance that the wastes are isolated within the storage area away from pathways to the public.		3	0.6	0.2	0.6	0.2	0.9	0.3	1.2	0.4	1.5	0.5	2.1	0.7	0.3	0.1
2	Geomorphic conditions either will not vary significantly from the present state or will occur to a predictable degree which can be accommodated in the facility design.		2	1.6	0.8	1.6	0.8	1.6	0.8	1.8	0.9	1.8	0.9	1.4	0.7	1.8	0.9
3	Structure related issues to include: Slope and geotechnical stability		3	2.7	0.9	2.7	0.9	2.7	0.9	2.7	0.9	2.7	0.9	2.4	0.8	2.7	0.9
4	The immediate area of the site is in strata of minimal groundwater flow.		3	0.9	0.3	0.9	0.3	0.9	0.3	0.9	0.3	0.6	0.2	1.5	0.5	0.9	0.3
5	Geological strata combined with engineering barriers shall provide a minimum permeability for aquifer protection.		3	2.4	0.8	2.4	0.8	2.4	0.8	2.4	0.8	2.4	0.8	2.4	0.8	2.4	0.8
6	Siting consideration should include bedrock and surface integration including the nature and extent of bedrock material.		2	1.6	0.8	1.2	0.6	1.2	0.6	1.8	0.9	1.4	0.7	2.0	1	1.8	0.9
7	Siting consideration should include minimal relative presence of fractures or faults.		2	1.2	0.6	1.2	0.6	1.2	0.6	1.6	0.8	1.6	0.8	1.6	0.8	1.6	0.8
8	Consideration should be given to the relative depth to bedrock and groundwater, including seasonal fluctuations for groundwater.		3	0.9	0.3	0.6	0.2	0.3	0.1	1.5	0.5	1.5	0.5	0.3	0.1	0.6	0.2
9	The site will not impact nor be impacted by surface water.		2	2.0	1	2.0	1	2.0	1	1.8	0.9	1.8	0.9	1.8	0.9	1.8	0.9
10	Relative distance to nearest discharge area to include consideration of groundwater flow direction and travel time.		3	0.6	0.2	0.6	0.2	0.6	0.2	0.9	0.3	0.6	0.2	1.5	0.5	0.6	0.2
11	The terrain is such that good drainage exists for movement of precipitation away from the storage area, and such that water and wind erosion will be minimal.		1	1.0	1	1.0	1	1.0	1	1.0	1	1.0	1	0.9	0.9	1.0	1
Public Protection			27.0	15.5		14.8		14.8		17.6		16.9		17.9		15.5	

SITING CRITERIA				Alternative Sites													
				Industrial Area						Buffer Zone							
				IA - West		IA - East		Solar Ponds		NSL		ESF		SE Quad		SW Quad	
		Weight %	Total Available Points	Points Scored	multi factor 0-1	Points Scored	multi factor 0-1	Points Scored	multi factor 0-1	Points Scored	multi factor 0-1	Points Scored	multi factor 0-1	Points Scored	multi factor 0-1	Points Scored	multi factor 0-1
	Category 3, Site Special Issues - Ability of the candidate site to provide a "footprint" that allows timely construction of a facility to occur. (schedule criteria)	15															
1	Ability of the site to support the Site Vision and Rocky Flats Conceptual Vision (Vision) objectives.		3	2.1	0.7	2.4	0.8	3.0	1	0.3	0.1	0.3	0.1	0.3	0.1	0.3	0.1
2	Impacts from existing utility, sewer, process waste, or communications lines.		2	1.2	0.6	0.4	0.2	0.8	0.4	1.8	0.9	1.6	0.8	2.0	1	2.0	1
3	Impacts from security.		1	0.9	0.9	0.9	0.9	0.4	0.4	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
4	Impacts from Plutonium consolidation or residue stabilization activities.		1	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
5	Impacts from deactiviation activities.		2	1.2	0.6	1.0	0.5	1.4	0.7	1.6	0.8	1.8	0.9	1.8	0.9	1.8	0.9
6	Impacts from current RCRA units.		2	1.8	0.9	0.4	0.2	1.4	0.7	2.0	1	2.0	1	2.0	1	2.0	1
7	Impacts from mineral rights issues or other easements.		2	1.2	0.6	1.8	0.9	1.8	0.9	0.8	0.4	1.8	0.9	2.0	1	1.2	0.6
8	Ability to collocate additional waste management cells in the same vicinity.		2	1.6	0.8	1.2	0.6	1.6	0.8	2.0	1	2.0	1	2.0	1	1.6	0.8
	Site Special Issues		15.0	10.8		8.9		11.2		10.2		11.2		11.8		10.6	
	Category 4, Cost Criteria	15															
1	Cost of engineering and construction of protective measures.		3	2.1	0.7	1.5	0.5	1.5	0.5	2.4	0.8	2.1	0.7	2.1	0.7	2.1	0.7
2	Cost of location preparation *including building* demolition, subsurface utility line removal and rerouting, access requirements, and power/facility requirements above the basic RWSF		3	2.1	0.7	1.5	0.5	1.8	0.6	2.4	0.8	2.4	0.8	2.4	0.8	2.4	0.8
	Cost Criteria		6	4.2		3.0		3.3		4.8		4.5		4.5		4.5	

SITING CRITERIA				Alternative Sites													
				Industrial Area						Buffer Zone							
				IA - West		IA - East		Solar Ponds		NSL		ESF		SE Quad		SW Quad	
		Weight %	Total Available Points	Points Scored	multi factor 0-1	Points Scored	multi factor 0-1	Points Scored	multi factor 0-1	Points Scored	multi factor 0-1	Points Scored	multi factor 0-1	Points Scored	multi factor 0-1	Points Scored	multi factor 0-1
	Category 5, Regulatory Support - State Principles for On-Site Disposal of Contaminated Materials (27-February-95 letter from Tom Looby to Jack McGraw and Mark Silverman)	15															
1	"The number of disposal sites must be minimized. We (CDPHE) suggest one centralized site be chosen for consolidation of contaminated materials."		2	1.6	0.8	1.4	0.7	1.8	0.9	1.4	0.7	1.2	0.6	1.2	0.6	1.2	0.6
2	"Every effort should be made to site a centralized disposal facility in an area of optimal geologic parameters preferably within, or close to the IA."		3	2.1	0.7	2.1	0.7	2.1	0.7	1.8	0.6	1.8	0.6	1.8	0.6	1.8	0.6
3	"Any disposal facility must be designed and built as a state of the art disposal facility that meets or exceeds all permitting and regulatory requirements. This includes siting, design, long term protection, and performance requirements."		3	1.8	0.6	1.8	0.6	1.8	0.6	1.8	0.6	1.8	0.6	1.8	0.6	1.8	0.6
4	A permitted centralized disposal facility provides DOE the greatest degree of future applicability and utility. As such, we believe that a centralized disposal facility should be designed with the intent to permit it from a RCRA/CHWA perspective.		2	1.6	0.8	1.6	0.8	1.6	0.8	1.6	0.8	1.6	0.8	1.6	0.8	1.6	0.8
5	"Any disposal site at RFETS should be located in areas that have limited future land use potential and will be controlled by DOE until the interred waste no longer presents a risk to human health or the environment."		3	1.5	0.5	2.1	0.7	2.7	0.9	1.2	0.4	1.2	0.4	0.9	0.3	0.9	0.3
Regulatory Support			13.0	8.6		9.0		10.0		7.8		7.6		7.3		7.3	

Table C-2 RWSF Location Criteria Detail

SITING CRITERIA				Alternative Sites													
				Industrial Area						Buffer Zone							
				IA - West		IA - East		Solar Ponds		NSL		ESF		SE Quad		SW Quad	
		Weight %	Total Available Points	Points Scored	multi factor 0-1	Points Scored	multi factor 0-1	Points Scored	multi factor 0-1	Points Scored	multi factor 0-1	Points Scored	multi factor 0-1	Points Scored	multi factor 0-1	Points Scored	multi factor 0-1
	Category 6, Other Stakeholder Concerns	15															
1	General public perception/acceptance		2	1.4	0.7	1.4	0.7	1.6	0.8	0.8	0.4	0.6	0.3	0.4	0.2	0.4	0.2
2	Municipal or County acceptance.		2	1.2	0.6	1.4	0.7	1.4	0.7	0.4	0.2	0.4	0.2	0.2	0.1	0.2	0.1
3	DOE Orders		2	1.2	0.6	1.2	0.6	1.2	0.6	1.2	0.6	1.2	0.6	1.2	0.6	1.2	0.6
4	NEPA		3	2.1	0.7	2.1	0.7	2.1	0.7	1.8	0.6	1.8	0.6	1.8	0.6	1.8	0.6
	Other Stakeholder Concerns		9.0	5.9		6.1		6.3		4.2		4.0		3.6		3.6	

Evaluate the seven locations (e.g., IA-East, IA-West) against the specific issues (for location, see Figure 1). The evaluation of the seven locations against Category 2 was accomplished with a series of maps displaying geologic, geomorphology, and hydrogeologic conditions (see Figures 2 through 7).

1. Evaluate and assign a number between 0-1 for each location on the matrix (e.g., IA-West, IA-East) against each specific issue with 0 being a fatal flaw that would preclude the location from being selected to 1 being the most favorable circumstance for that criteria (see Table C-2 for assigned numbers).

2. Multiply the score assigned to the specific issue in step 1 above (0 to 1) by the value assigned to the specific issue (between 1 and 3).

3. Sum the above products within each of the specific issues, as shown in Table C-2. There is a total of 35 specific issues illustrated in Table C-3, Criteria Issues:

Table C-3 Criteria Issues

Category	Criteria	Issues
1	Corrective Action Management Unit (CAMU) Criteria	5
2	Public Protection (Geotechnical and Hydrological Criteria)	11
3	Site Special Issues	8
4	Cost Criteria	2
5	Regulatory Support	5
6	Other Stakeholder Concerns	4
	Total	**35**

4. Divide the above sums by the total points and multiply by the weighting factor of that category, which in all cases is either 15 or 20%. The total available points assigned are 83, and are distributed as illustrated in Table C-4, Criteria Points.

Table C-4 Criteria Points

Category	Name	Points
1	Corrective Action Unit (CAMU) Criteria	13
2	Public Protection (Geotechnical and Hydrological Criteria)	27
3	Site Special Issues	15
4	Cost Criteria	6
5	Regulatory Support	13
6	Other Stakeholder Concerns	9
	Total	**83**

5. Sum the weighting factor of the six categories for the final ranking of the location. The overall ranking is summarized in Table C-5, RWSF Location Criteria Summary.

Each location was thus given an overall ranking between 0 and a 100%, with 100% being the most favorable location for the siting of a RWSF.

C.2.3 SCREENING PROCESS

A basic assumption made was that the entire Site as shown in Figure 1 would be included in the siting study. Category 2 includes the geologic, hydrogeologic, and geomorphologic aspects of the siting study. A series of maps were produced to assist in this evaluation. Additionally a map addressing ecology issues was included because these issues are best illustrated on a map. There are seven:

- Figure 1, Site Location Map, shows the location of building, roads, and the seven locations carried through in this evaluation.
- Figure 2, Hydrogeological Conditions, includes the depth to the water table and the area encompassed by 100-year flood plain.

Table C-5 RWSF Siting Criteria Summary

SITING CRITERIA				Alternative Sites													
				Industrial Area						Buffer Zone							
				IA - West		IA - East		Solar Ponds		NSL		ESF		SE Quad		SW Quad	
		Weight %	Total Available Points	Partial %	Points Scored	Partial %	Points Scored	Partial %	Points Scored	Partial %	Points Scored	Partial %	Points Scored	Partial %	Points Scored	Partial %	Points Scored
1	CAMU CRITERIA	20	13.0	15.1	9.8	14.6	9.5	15.8	10.3	16.2	10.5	15.7	10.2	15.7	10.2	15.7	10.2
2	PUBLIC PROTECTION	20	27.0	11.5	15.5	11.0	14.8	11.0	14.8	13.0	17.6	12.5	16.9	13.3	17.9	11.5	15.5
3	SITE SPECIAL ISSUES	15	15.0	10.8	10.8	8.9	8.9	11.2	11.2	10.2	10.2	11.2	11.2	11.8	11.8	10.6	10.6
4	COST CRITERIA	15	6.0	10.5	4.2	7.5	3.0	8.3	3.3	12.0	4.8	11.3	4.5	11.3	4.5	11.3	4.5
5	REGULATORY SUPPORT	15	13.0	9.9	8.6	10.4	9.0	11.5	10.0	9.0	7.8	8.8	7.6	8.4	7.3	8.4	7.3
6	OTHER STAKEHOLDER CONCERNS	15	9.0	9.8	5.9	10.2	6.1	10.5	6.3	7.0	4.2	6.7	4.0	6.0	3.6	6.0	3.6
	TOTALS	**100%**	**83.0**	67.6%	**54.8**	62.5%	**51.3**	68.3%	**55.9**	67.4%	**55.1**	66.1%	**54.4**	66.4%	**55.3**	63.4%	**51.7**

- Figure 3, Geological and Geotechnical Conditions, includes steep, color-coded slope areas for slopes 15-20%, 20-30%, and greater than 30% and inferred faults traces.

- Figure 4, Structure Base of Alluvium, drawn on the base of the alluvium (top of bedrock).

- Figure 5, Thickness of Alluvium, show the thickness of the Rocky Flats Alluvium.

- Figure 6, Ecology and NEPA, shows the location of seeps, wetlands, and Preble's Meadow Jumping Mouse probable habitat, a wildlife species that is being considered for listing as a species of concern, or a threatened and endangered species.

- Figure 7 Adverse Conditions (a combination of figures 2, 3, and 6 for a RWSF location) delineates three of the major potentially limiting criteria, the 100-year floodplain, steep slopes and the location of wetlands, seeps, and the Preble's Meadow Jumping Mouse habitat. Areas highlighted on this map have been removed from future consideration in this siting study because the presence of one or more of these aspects presents a major obstacle for locating a RWSF.

This initial screening of the Site reduced the number of locations being addressed. Seven locations are being carried forward in this study, four in the buffer zone and three located within the IA of the Site, as shown in Figure 1.

The four areas in the buffer zone are:

- The New Sanitary Landfill (NSL)

- An area near the East Spray Fields (ESF)

- An area in the Southwest Quadrant (SW Quad) of the buffer zone

- An area in the Southeast Quadrant (SE Quad) of the buffer zone

The three areas in the IA are:

- An area on the west side of the Industrial Area - (IA-West)

- An area on the southeast side of the Industrial Area - (IA-East)

- An area including the Solar Ponds 207B (North, Central, and South) and the land immediately adjacent and to the east (IHSS 165 and IHSS 176)

These seven locations are then carried on through the study and evaluated against the six general criteria categories. The scored matrix of location versus criteria and the values associated with the different combinations are shown in Table C-2.

C.2.4 ANALYSIS

The summary of the criteria evaluation is presented in Table C-5.

C.2.4.1 Corrective Action Management Unit (CAMU) Criteria

"The CAMU will facilitate the implementation of a reliable, effective, protective, and cost-effective remedy."

- A reliable, effective, and protective facility can be engineered at any of the locations being considered. The cost-effective component of this criteria ranges significantly from location to location, and is partially dependent on the RWSF design alternative selected. Locating any of the design alternatives within the IA is less cost-effective because of the infrastructure currently in place, such as building and buried and overhead utilities, that would have to be removed, rebuilt at another location, or re-routed.

- IA-West, IA-East, and Solar Ponds, all located within the IA, would be the less cost-effective options.

- NSL, ESF, SE Quad, and SW Quad locations located in the buffer zone would be the more cost-effective options.

"Remediation waste management activities associated with CAMU cannot create unacceptable risks to human health or the environment from exposure to hazardous waste or hazardous constituents."

- the locations within the IA would have a slight advantage in terms of transporting waste. Most of the waste that is being targeted for the RWSF would originate in the IA, and haul distances to a facility in the IA would be less than to a facility outside the IA.

"The CAMU shall include uncontaminated areas of the facility, only if including such areas for the purpose of managing remediation waste is more protective than management of such wastes at contaminated areas of the facility."

- NSL, SW Quad, and SE Quad locations are not in IHSSs or potential areas of concern (PAC). The designation of a CAMU to any of these locations would not be more protective than construction of the same facility within the IA on an IHSS.

- IA-West and IA-East locations are not within IHSSs or PACs; they are, however, located in the IA, adjacent to known contamination, or adjacent to, or within areas of, the location that have been subject to significant industrial uses, such as office buildings, waste storage buildings, production buildings, parking lots, paved roads, and buried and overhead utilities.

- The Solar Ponds and ESF are located within areas that have, in part, been designated IHSSs. The Solar Ponds location overlaps the Triangle Area, IHSS 165; the Contractor Storage Yard, IHSS 176; and the Solar Ponds, IHSS 207B. Managing remediation waste in this area has the advantage of managing waste in a secure area and reducing the size of the overall footprint of contamination at the Site.

- The ESF location overlaps IHSSs 216.2 and 216.3; however, these IHSSs have been identified as having no risk associated with them and have been recommended to go to no further action.

"The CAMU shall expedite the timing of remedial activity implementation, unless to do so would be inconsistent with 6 CCR 1007-3, 264.552(c)(1) or (c)(2)."

- The timing of remedial activity implementation is more dependent on the RWSF design alternative selected and the permitting process than on the location selected. This criteria is approximately the same for all locations being considered.

The CAMU shall enable the use, "as appropriate, treatment technologies (including innovative technologies) to enhance long-term effectiveness of remedial actions at the facility by reducing the toxicity, mobility, or volume of wastes that will remain in place after closure."

- The ability of the CAMU to use these treatment technologies, when appropriate, is more or less independent of the location selected and is approximately the same for all locations in the study.

C.2.4.2 Public Protection (Geotechnical and Hydrological Criteria)

"The geological and hydrogeologic conditions of a location in which hazardous waste is stored should provide reasonable assurance that the wastes are isolated within the storage area away from pathways to the public."

- Hydraulic conductivities of foundation soil materials (Rocky Flats Alluvium) typically occur in the 10^{-3} to 10^{-5} cm/sec range. Lower hydraulic conductivity values in the range of 10^{-6} to 10^{-7} cm/sec have been measured for the underlying weathered claystone bedrock. All of the locations are located in recharge areas associated with the Rocky Flats Alluvium and colluvial deposits, and many are located near discharge areas. The depth to the Fox Hills aquifer is greater than 500 feet over most of the Site and this interval consists mainly of low permeability claystones with hydraulic conductivities in the range of 10^{-6} to 10^{-7} cm/sec.

- The estimates of lateral groundwater flow travel times in the underlying surficial materials from the proposed waste locations to their nearest discharge points are well below a 1,000 years for all of the locations under consideration. The calculated travel times typically range from several years to several decades. The presence of significant groundwater discharge points (springs and seeps) in hydraulically downgradient areas of the SW Quad (Antelope Springs), NSL (Lindsey Ranch Springs), and potentially the ESF location, tend to reduce the suitability of these locations because of the potential ecological impacts associated with sensitive habitats issues. The location least affected by short groundwater travel times is the SW Quad location because groundwater is assumed to flow through bedrock materials (hydraulic conductivities 10^{-6}-10^{-7} cm/sec) rather than the more permeable alluvium.

- Water losses from location operations via leaking pipes and general housekeeping practices are currently believed to contribute an unknown but potentially significant amount of recharge to the groundwater in the Site IA. It is expected that the elimination of anthropogenic recharge sources related to cessation of location operations and building closures under the Site Vision will result in a lowering of water levels in the IA similar to that observed in many IA well hydrographs following the termination of plant production operations in 1990.

"Geomorphic conditions either will not vary significantly from the present state or will occur to a predictable degree which can be accommodated in the facility design."

- This is not a major factor in the overall siting study; all locations have approximately the same geomorphic conditions with the degree of erosion occurring at a predictable rate and can be accommodated in the facility design. The SE Quad location is rated lower in this category because the protective cover of the Rocky Flats Alluvium has been removed by erosion and escarpment retreat.

"Structural-related issues include slope and geotechnical stability, as shown in Figures 3 and 7."

- Areas with steep slopes (slopes greater than 15%) have been eliminated from the siting study. There is a steep slope to the north of the Solar Ponds location; the footprint to the facility would be positioned, however, as far south of the slope as the design would allow and is not considered to be a limiting siting factor. Geotechnical stability of foundation soils is not expected to be a problem at any of the locations. This consideration will be addressed by a field geotechnical investigation performed at the selected location during the feasibility-assessment phase of the program.

"The immediate area of the location should be in strata of minimal groundwater flow."

- All of the locations have minimal groundwater flow, however, the SE Quad location is situated in an area considered more suitable compared to the other locations. At the SE Quad location, the RWSF would be built on weathered bedrock materials that have a significantly lower permeability than either the surrounding thin, colluvial soil veneer or Rocky Flats Alluvium.

"Geological strata combined with engineering barriers shall provide a minimum permeability."

- The design of the facility at any of the candidate locations would incorporate an engineered barrier that would provide a minimum permeability of 10^{-7} cm/sec for protection of domestic or agriculture aquifers. Additional protection of the regionally important Laramie/Fox Hills aquifer is provided by several hundred feet of intervening, low-permeability claystone aquitard materials comprising the upper Laramie and Arapahoe formations. Downward migration from the unconfined aquifer is thought to be nonexistent based on existing data (EG&G, 1995a).

Siting consideration should include "bedrock and surface integration including the nature and extent of bedrock material."

- The upper Laramie Formation is an extensive aquitard beneath all locations under consideration (maximum thickness beneath the Site is greater than 500 feet) and forms an effective and continuous low-permeability barrier to downward vertical groundwater flow. Local variations in shallow bedrock lithology caused by the presence of small, discontinuous bodies of subcropping Arapahoe formation sandstones are observed in the IA, notably at the Solar Ponds and IA-East locations. These sandstones are capable of both vertical and lateral groundwater transport, but vertical flow to deeper sandstones and the Laramie/Fox Hills aquifer is thought to be nonexistent. Sites with thinly saturated alluvium and subcropping sandstones, such as those found at the Solar Ponds and IA-East areas, have the greatest potential for groundwater interchange between alluvial and bedrock units. The sandstones from the Arapahoe and Laramie formations, however, are discontinuous and isolated, with fewer sandstone lens present in the lower part of the formation.

"Siting consideration should include minimal relative presence of fractures or faults."

- Bedrock fracturing is potentially important in areas of thinly saturated alluvium (Solar Ponds, ESF, and IA-East locations), where a significant portion of alluvial groundwater may recharge the bedrock, or at the SE Quad location, where liner materials would be in direct contact with bedrock.

Groundwater flow in fractured claystone bedrock is thought to be minimal because of limited fracture densities and small fracture apertures observed in core samples across the location. Fracture densities are observed to decrease with depth.

- The inferred bedrock faults at the Site, as shown in Figures 3 and 4, are not considered to pose a seismic risk (EG&G, 1995b), according to the Nuclear Regulatory Commission definition (10 CFR Part 100, Appendix A) (NRC, 1990 and 1991), because the Rocky Flats Alluvium is not deformed over the intensely fractured areas of the Laramie Formation at the Site.

  - Solar Ponds and IA-East. There is an inferred north-to-south-orientated bedrock fault through the Solar Ponds that continues south through the IA-East location (EG&G 1995a). The inferred fault appears to be located hydraulically upgradient from the Solar Ponds location which would remove it as a potential groundwater pathway. The trace of this inferred fault also bisects the IA-East location from north to south.

  - IA-West. There is an inferred northeast-to-southwest trending bedrock fault through the IA-West location. This fault is located hydraulically downgradient from the IA-West location and represents a potential groundwater pathway to deeper sections of the Laramie Formation.

  - ESF. There is an inferred northeast-to-southwest bedrock fault trending fault through the ESF location. The fault is located hydraulically upgradient from the location and removes it as a potential groundwater pathway.

  - NSL, SE Quad, and SW Quad. There are no mapped or inferred faults in these areas.

  - A preliminary evaluation of potential vertical groundwater movement along fault zones at the Site using environmental isotopes as hydrologic tracers has indicated that fault zones probably transmit little, if any, groundwater preferentially downward relative to flow in undisturbed, unweathered bedrock zones (memorandum to A. Primrose from R. Smith dated November 22, 1995).

Consideration should be given to the "relative depth to bedrock/groundwater, including seasonal fluctuations for groundwater."

- Bedrock depths range from less than an estimated 5 feet at the SE Quad location to over 40 feet at the NSL, ESF, and SW Quad locations. Saturated alluvial thicknesses at the candidate locations vary as a function of distance from drainages, configuration of bedrock topography, and seasonal recharge. Generally, saturated thicknesses are greatest in the spring (April, May, and June) and may fluctuate anywhere from a few feet to as much as 20 feet depending on local hydrologic and seasonal recharge conditions.

- Precipitation for the spring of 1995 has been estimated to be the greatest in a 102-year period based on precipitation records from Boulder, Colorado. Seasonally high water tables, in some cases within a foot of ground level, were measured or estimated at many of the locations in 1995. The locations with the deepest water tables (seasonal peaks greater than 10 feet below ground level) include ESF and the NSL.

- IA-West, IA-East, and Solar Ponds. As shown in Figure 2, the average water table in the IA is +/-10 feet from the surface (Ref.: EG&G, Hydrogeologic Characterization Report for the Rocky Flats Environmental Technology Site, April 1995). At the IA-West location, the minimum depth to groundwater (historical highs) was recorded or estimated during 1995 and ranged from 0.0 to 8.7 feet below ground level in the six monitoring wells in and around the location. In this same timeframe at the Solar Ponds location, the depth to groundwater ranged from 1.0 to 4.8 feet. Well coverage at the IA-East location is less extensive compared to the other IA locations, and it is assumed that water-level conditions were similarly shallow based on historical water-level records and location-specific hydrologic conditions.

  - NSL. The concerns related to water-table depth at the NSL are less than those associated with the IA. The minimum depth to groundwater at the NSL location was measured at 26 feet (well 0190) in 1995, which makes this the most favorable location in terms of the seasonal fluctuation criteria. The water table typically occurs in the 30- to 50-foot below grade range under normal (non-peak) hydrologic conditions.

  - ESF. Water level records of four wells at the ESF location indicate that the minimum depth to water expected in this area is about 20 feet, with an average depth of between 25 to 30 feet. The alluvium at this location generally has a saturated thickness of less than 5 feet, with significant unsaturated areas occurring during seasonal watertable lows.

  - SE Quad. There is a paucity of water-level data in this area because of the lack of monitoring well coverage. The majority of the surficial deposits in this area most likely exist in a largely unsaturated condition. A shallow water table in the underlying weathered bedrock material, however, may exist and cannot be ruled out without more information.

  - SW Quad. Depth to groundwater at the SW Quad location is 0 to 20 feet with a saturated thickness of between 30 and 40 feet. Groundwater in this area becomes more shallow in an eastward direction toward Antelope Springs, as indicated by monitoring well data. The minimum water-table depth in areas west of Antelope Springs is estimated to be less than 5 feet.

"The site will not impact nor be impacted by surface water."

- None of the locations are located in areas that will be impacted by surface water. The locations are not expected to have a significant impact on surface water, although slight reductions in flow at nearby springs and seeps may be experienced because of a loss of recharge area. This situation might exist at the SW Quad, NSL, and ESF locations where free-flowing springs contribute directly to stream flow.

"Relative distance to the nearest discharge area should include consideration of groundwater flow direction and travel time."

- The relative distance to the nearest discharge areas is relatively short for most of the locations being considered.

  - IA-West and IA-East. These locations lie astride the subsurface drainage divide between the ephemeral Woman and Walnut Creeks. The nearest point of discharge are the seeps that are expressed near the base of the alluvium on the south-facing slopes of the Woman Creek Drainage. These wetlands areas are approximately 250 feet south of the IA-West location. Groundwater flow from the IA-East location south of the drainage divide would flow toward Woman Creek but is captured by the French Drain along the 881 Hillside.

  - Solar Ponds. This location lies astride the subsurface drainage divide between the North and South Walnut Creeks. The Interceptor Trench System (ITS) adjacent to, and north of, the Solar Ponds captures part of the groundwater flow to the north. The flow to the north not captured by ITS moves toward South Walnut Creek and eventually enters the groundwater system associated with this drainage. The nearest point of discharge to South Walnut Creek is approximately 250 feet south of the Solar Ponds location.

  - NSL. This location lies astride the subsurface drainage divide between the ephemeral Rock Creek to the north and North Walnut Creek to the south. Surface expressions of groundwater in the forms of seeps are evident along the base of the alluvium in the Rock Creek Drainage about 1500 feet to the northeast. On the south side of the drainage divide the nearest discharge to surface water would be about 500 feet south to the upper reaches of North Walnut Creek.

  - ESF. This location lies on the subsurface drainage divide between Woman and Walnut Creeks. The part of this candidate area that lies on the Woman Creek side of the watershed is unsaturated, which would indicate that groundwater from this location in all likelihood does not flow into Woman Creek. The part of the location on the Walnut Creek side of the location discharges into a series of seeps located 200 to 1000 feet north of the location (depending on the location of the facility) at the base of the alluvium that discharges through surface flow into Walnut Creek.

- SW Quad. The groundwater direction of flow from this location is to the northeast and discharges into Antelope Springs, which is adjacent to the location. The location is within the Woman Creek drainage basin.

- SE Quad. This candidate is located on the north side of the Woman Creek drainage. Subsurface data are sparse in this area, but the area is not located on the Rocky Flats Alluvium. The surficial geology of this location is weathered claystones, siltstones, and sandstones of the Arapahoe and the underlying Laramie Formations (EG&G, 1995a). The location potentially has no saturated unconsolidated surficial deposits.

"The terrain is such that good drainage exists for movement of precipitation away from the storage area, and such that water and wind erosion will be minimal."

- This criteria is essentially the same for all locations, either good drainage already exists or a drainage system can be engineered to accommodate the needs of this requirement. The SW Quad has a slightly poorer drainage system than the other locations.

C.2.4.3 Site Special Issues

The ability of the location to support the Site Vision objectives: Under the Site Vision, all nuclear materials will be removed from the Site and the DOE will remediate the Site in a manner consistent with reasonably foreseeable future projected land (see Figure 8, Conceptual Site Land Uses) and water uses.

- The reasonably foreseeable future land use of the buffer zone varies from unrestricted to restricted open space, whereas the IA is projected as either an industrial use area or as a capped area.

  - Solar Ponds would be an ideal candidate to support the Site Vision because of the future land use of the IA and its location within the footprint of the capped area.

  - IA-East and IA-West could, with extensive modification to the footprint of the capped area, support the RFCA. The IA-West location is in a non-contaminated area in the IA.

  - The candidate locations, NSL, ESF, SW Quad, and SE Quad, do not support the Site Vision because utilization of these locations would involve placing contamination in previously uncontaminated areas.

- Impacts from existing utility, sewer, process waste, or communications line:

  - IA-West, IA-East, and Solar Ponds. The three locations within the IA all have significant amounts of utility lines, sewer lines, and other infrastructure, either buried or above ground, that would require removal or replacement. (listed in Table C-6, "In-place Infrastructure"). Impacts would also include demolition of buildings within the footprint, storage of RCRA waste currently located in buildings at these locations (IA-East and the Solar Ponds), and construction of a portal and security fence for the Solar Ponds location. The order-of-magnitude costs generated for the preparation of a location are in Table C-7.

Table C-6 In-place Infrastructure

Location	Area	Infrastructure
New Sanitary Landfill	Underground	Telephone main
		Electrical - 208V
		Water Line - 3@ (abandoned)
	Overhead	Electrical Utilities - 208V
	Miscellaneous	Live Firing Range - Range Fan Area
	Buildings	None
Solar Ponds	Underground	Process Waste Lines - 3" and 8"
		Raw Water Lines - 4," 6" and 8"
		Domestic Cold Water - 4"
		Sewer Lines - 4", 8" and 12"
		Process Drains - 3", 6" and 8"
		Water Valves
		Culverts
		Telephone Lines
	Overhead	Electrical Utilities - 110V, 440V, 480V and 2400kV
		Helicopter Deterrent
		Power Poles
	Buildings(1)	228A, 228B, 910, 928, 964, 965, 967, and 990
IA-East	Underground	Electrical Utilities - 480V and 13.8kV
		Water Pipelines - 3", 6", and 10"
		Steam - 6" and 8"
		Gas Lines - 3"
		Sewer Lines - 4" and 12"
		Telephone Lines
		Foundation Drains
		Tunnel
		Culverts
		Alarms and Data Systems
		Storm Drains
		Vaults
	Overhead	Electrical - 2400V and 13.8kV
		Alarms
		Steam and Condensate
		Natural Gas
	Buildings	T886B, T886C, T893B, 902 Tent, 906, and ER Contractor Yard
IA-West	Underground	Electrical Utilities - 15V, 110V, 120V, 120/240V, 277V, 2400V, and 13.8kV
		Domestic Cold Water Pipelines - 4", 6", and 12@
		Raw Water Pipelines - 2", 4", and 12"
		Water Valves
		Culverts - 12", 18", and 20"
		Alarms - 1", 2" and 4"
		Sewer Lines - 4" and 8"
		Catch Basins
		Storm Drains - 15"
		Scanner
	Overhead	Electrical - 480V, 2400V, 13.8kV and Parking
	Buildings	T124A

(1) Only Building 964 will need to be removed if any design alternative other than the Abovegrade Storage Cell is the preferred alternative.

Table C-7 Order-of-Magnitude Costs for Site Preparation

Location	Construction Cost
IA-East	$14,800,000
Solar Pond	$11,900,000
IA-West	$2,200,000
NSL	$100,000

- Costs were not generated for the ESF, SW Quad, or the SE Quad locations. The preparation for these areas would fall between the costs of the IA-West and NSL.

- Impacts from security:

  - Security impacts would be approximately the same for all locations, except for the Solar Ponds. That area would need an access portal to allow for construction materials and workers to enter the PA, a perimeter fence to isolate the discharge to surface water would be about 500 feet south to the upper reaches of RWSF during both construction and post-construction activities, and a security staff during construction activities. The cost of the portal, fence, and security staff has been calculated as part of the preparation cost.

- Impacts from Pu consolidation or residue stabilization activities:

  - Impacts from Pu consolidation or residue stabilization activities are not a factor for the siting of a RWSF.

- Impacts from deactivation and decontamination (D&D) activities:

  - IA-West. Building T124A is located within the footprint and staging area (22 acres) of the abovegrade RWSF storage cell and would require demolition if this design option was selected. This building is currently scheduled for removal in fiscal year 2000, but that could easily be accelerated if the location were selected. The other design alternatives for this location all have smaller footprint and staging areas (approximately 10 to 12 acres) and would not require demolition of this building.

  - IA-East. There are several buildings and a contractor yard that would be impacted from siting the RWSF at IA-East. Building 906, the centralized waste storage facility, is the newest building at the Site and was specifically built for waste storage. The decommissioning of this facility has not been scheduled, and the current working assumption is that it will remain, at least, for the near term. The 902 Pad facility is a tent and the possibility exists to move it to another location without losing storage capacity. The contractor yard has a number of trailers and government- and contractor-owned stored equipment. The decommissioning of this area has not yet been scheduled and the working assumption is that it would remain open beyond 2003.

- Solar Ponds. Building 964 is located within the footprint of the Solar Ponds Area. It is a sheet metal building used as a RCRA storage facility. Demolition of the structure is straight forward and could be completed in 90 days assuming additional waste storage capacity becomes available. If the Abovegrade Storage Cell alternative is selected the footprint would be larger and also require the demolition of Buildings 228A, 228B, 928, 965, 910, and 990.

- NSL, ESF, SW Quad, and SE Quad. There are no buildings associated with these candidate's locations.

• Impacts from current RCRA units:

  - IA-East. Building 906, the centralized waste storage facility, is a RCRA storage facility. The decommissioning of this facility has not been scheduled, and the current working assumption is that it will remain until no longer required.

  - Solar Ponds. Building 964 is a RCRA storage facility located within the footprint of the Solar Ponds Area. Alternative storage capacity would have to be created before demolition of this structure.

  - IA-West, NSL, ESF, SW Quad, and SE Quad. There are no RCRA storage units located at these candidate locations.

• Impacts from mineral rights issues or other easements:

  - All mineral rights at the Site are either privately held, or, as with the NSL location, it is both privately and governmentally held (see Figure 9, Mineral Ownership). Alluvial thicknesses greater than 40 feet are potentially economic for the gravel resources.

  - NSL and SW Quad. Both locations have alluvial thicknesses greater than 40 feet.

  - IA-West. Alluvial thicknesses are 25 to 40 feet thick and do not constitute an economic resource.

- ESF. Alluvial thicknesses are 10-30 feet thick and do not constitute an economic resource.

- IA-East and Solar Ponds. Alluvial thicknesses are +/-10 feet thick and do not constitute an economic resource.

- SE Quad. Located off the Rocky Flats Alluvium, there are no gravel deposits at this location.

- Ability to collocate additional RWSFs in the same vicinity:

  - IA-West, NSL, ESF, SW Quad, and SE Quad. All have adequate space to location additional RWSF cells if needed.

  - Solar Ponds. The footprint shown in Figure 1 can accommodate approximately 400,000 cy.

  - The area around IA-East is restricted, with the 800 complex to the west, steep slopes to the south, and the security fence surrounding the PA to the north. Room for expansion would potentially be available to the east.

C.2.4.4 Cost Criteria

- The cost of engineering and construction of protective measures:

  - The cost of engineering and construction varies with the RWSF alternative selected. The cost of construction at the Solar Ponds would be greater than at other locations because of the additional requirements imposed by having to construct a materials and worker portal through the security fence into the PA, and the additional security that would be required.

- Cost of preparation of the location including building demolition, subsurface line removal and rerouting, access requirements and power/facility requirements above the basic RWSF:

  - The cost of preparation varies by location. The cost of preparation at the NSL location is approximately of $100,000. The preparation for the NSL location already under construction has mitigated the costs that would otherwise be associated with a RWSF at this location.

  - ESF, SW Quad, and SE Quad would require construction or upgrades to the roads leading to the locations; costs are estimated to be more than the NSL location ($100,000) but less than the costs of the IA-West location ($2.2 to $2.8 million).

- The locations within the IA, IA-West, IA-East, and Solar Ponds have considerable costs associated with preparation including building demolitions, subsurface line removal and rerouting access requirements. Costs for preparation range from approximately \$2.2 to \$2.8 million for IA-West, \$6.1 to \$14.5 million for the Solar Ponds, and \$15.2 to \$18.1 million for IA-East.

C.2.4.5 Regulatory Support

"The number of disposal sites must be minimized. We (CDPHE) suggest one centralized site be chosen for consolidation of contaminated materials." The following concepts have been evaluated in this study to ensure consistency with EPA and CDHPE desires, but because the RWSF being proposed is for storage, not disposal, some of these criteria may not be appropriate for siting a storage facility.

- Locating the RWSF at the Solar Ponds location minimizes the number of storage locations by locating the facility in an area that coincides with, and would ultimately be incorporated into, the larger cap, and is a component of the Site Vision. The IA-West and the IA-East locations could, with major revisions, support the Site Vision.

- The NSL, ESF, SE Quad, and the SW Quad locations would increase the overall areal extent of contamination by their location that is further away from the IA. The IA is where the bulk of the environmental waste at the Site is located.

"Every effort should be made to site a centralized disposal facility in an area of optimal geologic parameters preferably within or close to the Industrial Area (IA)."

- Optimal geological parameters at the Site reside in the locations outside of the IA. The NSL, ESF, and the SE Quad are preferred locations from an optimal geologic standpoint relative to the IA. However, all three locations are at a distance from the IA; the NSL is 2,000 feet northwest; ESF is 4,000 feet to the east; and the SE Quad is approximately 6,000 feet to the southeast of the PA.

- Optimal geological parameters do not exist within the IA, as discussed in Section 2.4.1, IA-West, IA-East, and the Solar Ponds are all within the IA.

"Any disposal facility must be designed and built as a state-of-the-art disposal facility that meets or exceeds all permitting and regulatory requirements. This includes (but not limited to) siting, design, long-term protection, and performance requirements."

- The alternatives considered will be built as a state-of-the-art storage facility and will meet or exceed all permitting and regulatory requirements. This criteria is the same for all locations being considered.

"A permitted centralized disposal facility provides DOE the greatest degree of future applicability and utility. As such, we believe that a centralized disposal facility should be designed with the intent to permit it from a RCRA/CHWA perspective."

- This criteria is the same for all locations being considered.

C.2.4.6 Other Stakeholder Concerns

- General public perception and acceptance:

  - For onsite management of remediation waste, the locations within the IA, IA-West, IA-East and the Solar Ponds would in all likelihood be more readily acceptable to the general public than storage in the buffer zone. The locations in the IA reduce the footprint of contamination at the Site, and other than offsite disposal, storage of the environmental waste in the IA may well be the most acceptable alternative to the general public. Also, the Interim Measure/Interim Remedial Action (IM/IRA) for closure in place of Solar Ponds has already been accepted by the public.

- Municipal or County acceptance:

  - The Jefferson County, Colorado Board of Commissioners Resolution No. CC94-654 states, "maintaining, in perpetuity, the undeveloped buffer zone of open space around Rocky Flats is a critically important environmental, safety, and health constraint which must be required as part of any and all alternatives actions proposed by the Department of Energy." The three locations within the IA, IA-West, IA-East and the Solar Ponds would support this resolution.

  - NSL, ESF, SW Quad, and SE Quad locations are located within the buffer zone and as such, constructing a RWSF at any of these locations would be counter to the desires of Jefferson County.

- DOE Orders:

  - The same DOE orders would apply equally to all locations.

- NEPA:

– NEPA issues would be addressed equally for all locations.

C.2.5 RESULTS FOR SELECTED LOCATIONS

The results of the above analysis are summarized in Table C-5. Overall, the Solar Ponds (68.3%) was ranked slightly higher then the IA-West (67.6%) location, and the NSL (67.4%) as a location for a RWSF at the Site.

In Category 1, CAMU, the ability to designate the location as a CAMU was in favor of the IA locations, in order: Solar Ponds; IA-East; and IA-West. The capacity to reduce the areal extent of contamination and not contaminate clean areas weighed heavily in favor of the IA locations. No fatal flaws were associated with this category at any of the seven locations carried through the evaluation.

In Category 2, Public Protection (Geotechnical and Hydrological Criteria), three of the buffer zone locations were ranked highest, in order: SE Quad; NSL; and ESF. The primary concern with the locations in the IA, (Solar Ponds, IA-West, and IA-East) is the elevated groundwater table; the concerns are somewhat mitigated, however, through the use of an above-grade design. No fatal flaws were associated with this category at any of the seven locations carried through the evaluation.

In Category 3, Site Special Issues, the SE Quad was evaluated as the highest, followed by Solar Ponds, and ESF locations. The three locations in the IA, IA-West, IA-East, and the Solar Ponds all received high ranking for the ability to support the Site Vision. However, the impacts of having to address issues with the existing infrastructure lowered the overall scores for the IA locations in this category. No fatal flaws were associated with this category at any of the seven locations carried through the evaluation.

In Category 4, Cost Criteria, the locations in the buffer zone are favored. All four buffer zone locations received higher ranking than the locations in the IA. The major factors were the costs associated with removing, rerouting, or replacing buildings and underground and overhead utilities in the IA. The Solar Ponds has the additional burden of having to construct a portal through the PA security fence, constructing a fence surrounding the location, and having a security staff available during construction and operation of the facility.

In Category 5, Regulatory Support, the support is clearly in favor of a location in the IA. The Solar Ponds location was ranked highest followed by IA-East and IA-West.

In Category 6, Other Stakeholder Concerns, the three locations within the IA, Solar Ponds, IA-East, and IA-West respectively, ranked the highest. The general public would likely be more receptive to placing remediation waste in areas that already contain some contamination rather than siting a RWSF at a location that has no history of contamination. The Jefferson County, Colorado Board of Commissioners, state their position in Resolution No. CC94-654 as "Maintaining in Perpetuity, the undeveloped buffer zone of 'Open Space' around Rocky Flats is a critically important environmental safety and health constrain which must be required as part on any and all alternative action proposed by the Department of Energy."

C.2.6 REFERENCES

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EG&G, 1995a, *Geological Characterization Report for the Rocky Flats Environmental Site*, March 1995.

EG&G, 1995b, *Evaluation of the Capability of Inferred Faults in the Vicinity of Building 371, Rocky Flats Environmental Technology Site, Colorado: Prepared by Geomatrix Consultants, Inc., for EG&G Rocky Flats, Inc.*, Draft Report, January 1995.

Environmental Guidance Regulatory Bulletin, Office of Environmental Guidance RCRA/CERCLA Division (EH-231)CAMU/TU Final Rule Issued May 12, 1993.

EPA, 1993, Federal Register, Part II, 40CFR Part 260, et. al. Corrective Action Management Units and Temporary Units; Corrective Action Provisions; Final Rule February 16.

Jefferson County Colorado Board of Commissioners, Resolution No. CC94-654.

Looby, Tom (CDPHE), 1995 to Jack McGraw (EPA), and Mark Silverman (DOE), subject matter: State principles for onsite waste management of contaminated materials, February 27.

Smith, R., 1995, Memorandum to Annette Primrose, November 22.

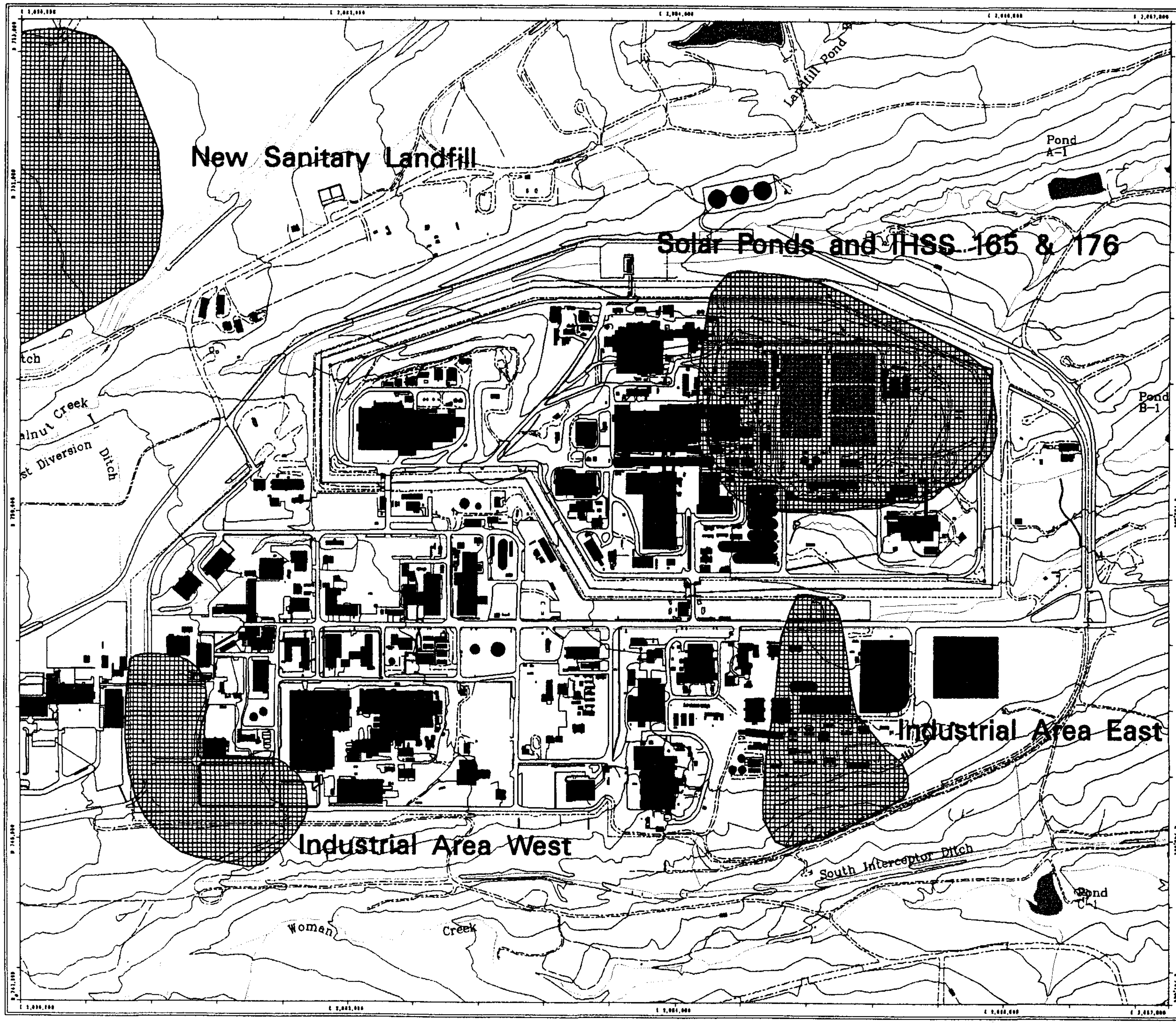

Figure 1
Location Map

EXPLANATION

Potential RWSF Sites

Standard Map Features

Buildings or other structures

Lakes and ponds

Streams, ditches, or other drainage features

Fences

Contours (20' intervals)

Rocky Flats boundary

Paved roads

Dirt Roads

Trails

DATA SOURCE:
Buildings, roads, and fences provided by Facilities Engr.
EG&G Rocky Flats, Inc. - 1991.
Hydrology provided by USGS - (date unknown)

N

Scale = 1 : 10380
1 inch represents approximately 863 feet

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

U.S. Department of Energy
Rocky Flats Environmental Technology Site

Prepared by:

RMRS Rocky Mountain Remediation Services, L.L.C.
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MAP ID: 97-0014

February 28, 1997

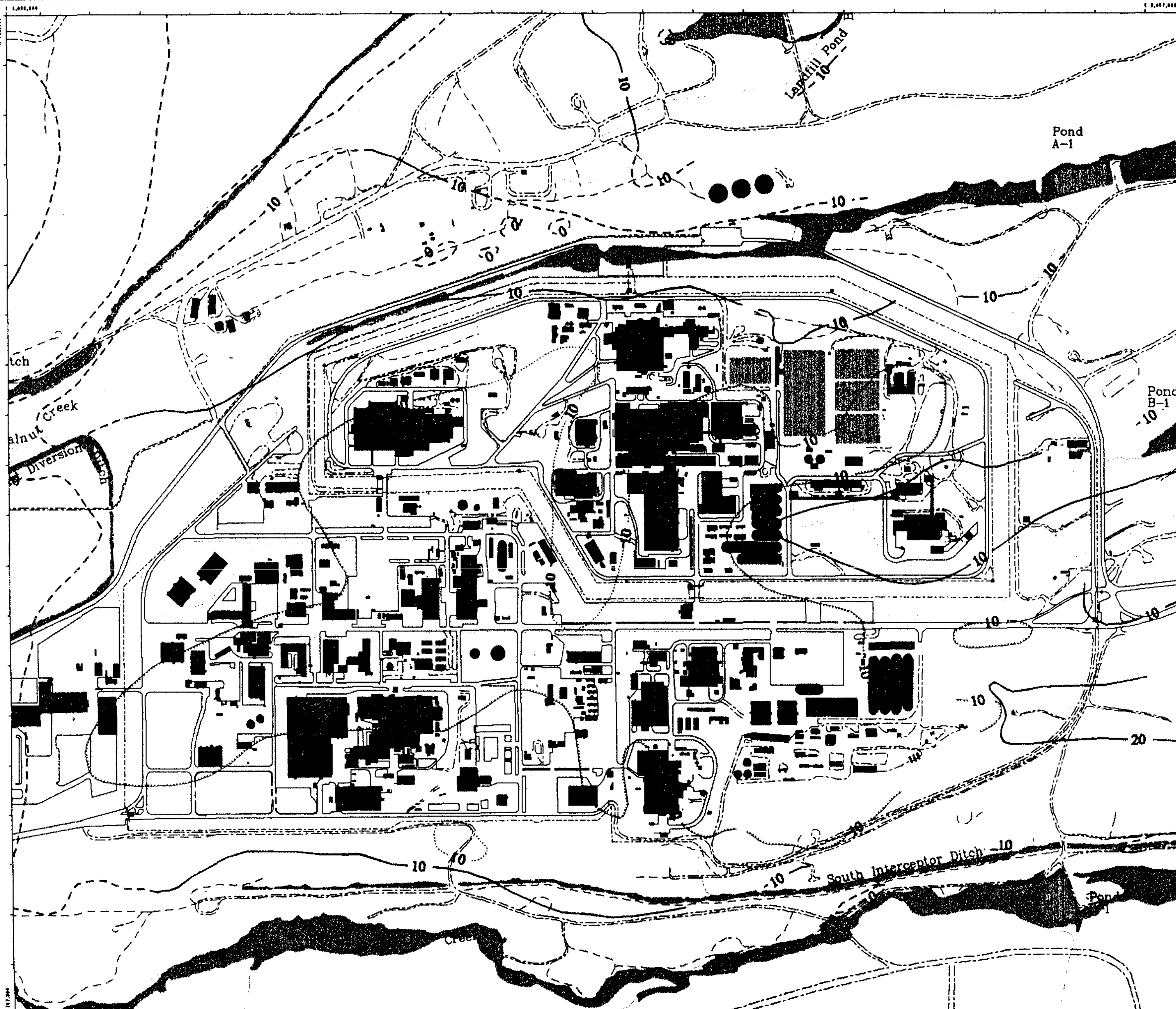

Figure 2
Hydrogeological Conditions

EXPLANATION

- Line of Equal Depth to Water (in feet)
- (dashed where inferred)
- Decreasing Line of Equal Depth to Water (in feet)
- (dashed where inferred)

Standard Map Features

- Buildings or other structures
- 100 year floodplain
- Lakes and ponds
- Streams, ditches, or other drainage features
- Fences
- Rocky Flats boundary
- Paved roads
- Dirt Roads
- Trails

DATA SOURCE:
Buildings, roads, and fences provided by Facilities Engr., EG&G Rocky Flats, Inc. - 1991.
Hydrology provided by USGS - (date unknown)

Scale = 1 : 10770
1 inch represents approximately 898 feet

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

U.S. Department of Energy
Rocky Flats Environmental Technology Site

Prepared by:
RMRS Rocky Mountain Remediation Services, L.L.C.

MAP ID: Draft

February 24, 1997

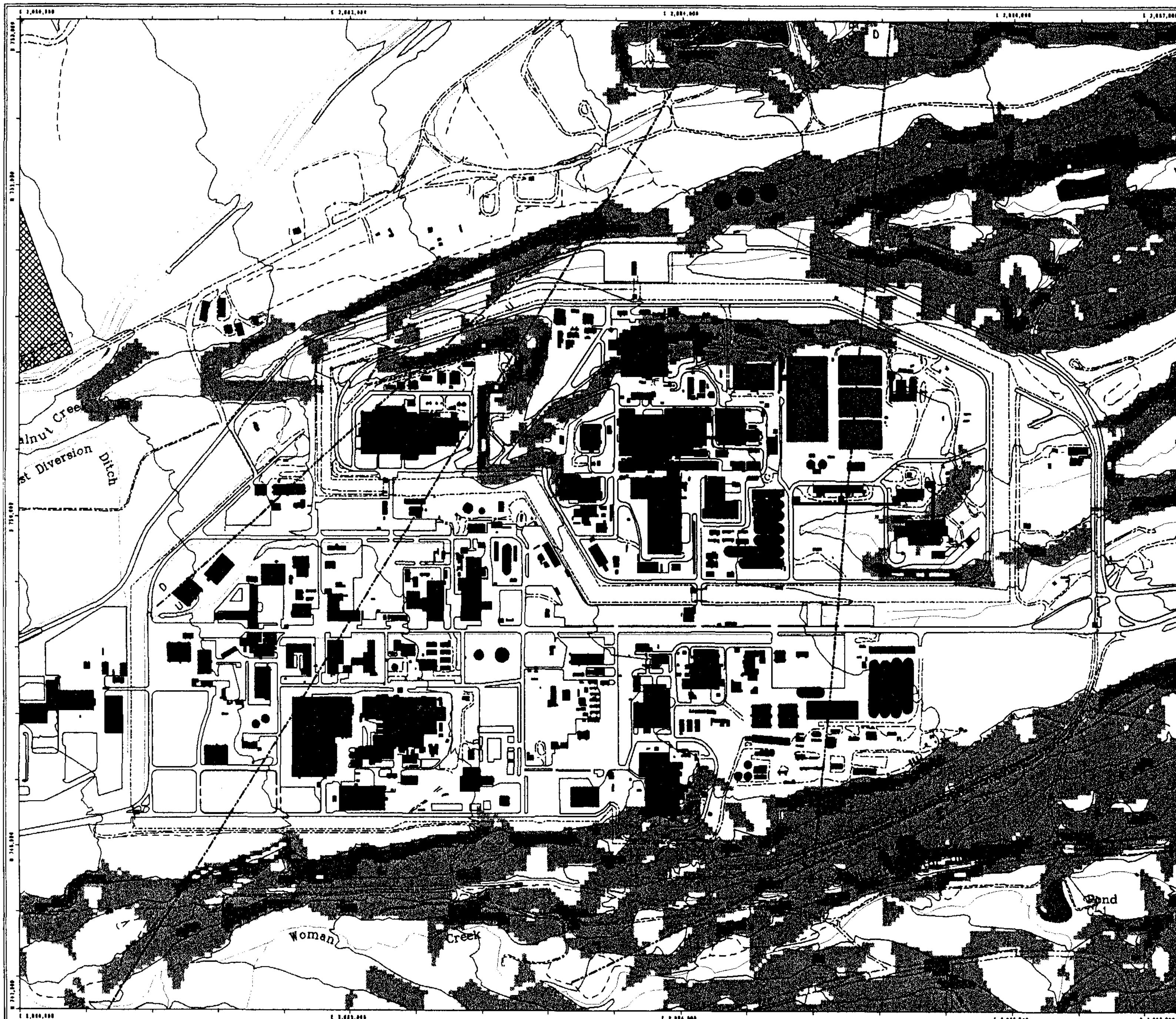

Figure 3
Geological and Geotechnical Conditions

EXPLANATION

Fault line - dashed where inferred

Slope Categories

Slope = 15% - 20%

Slope = 20% - 30%

Slope > 30%

Standard Map Features

Buildings or other structures

Lakes and ponds

Streams, ditches, or other drainage features

Fences

Contours (20' Intervals)

Rocky Flats boundary

Paved roads

Dirt Roads

Trails

DATA SOURCE:
Buildings, roads, and fences provided by Facilities Engr., EG&G Rocky Flats, Inc. - 1991.
Hydrology provided by USGS - (date unknown)

N

Scale = 1 : 10360
1 inch represents approximately 863 feet

200 0 400 800 Feet

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

U.S. Department of Energy
Rocky Flats Environmental Technology Site

Prepared by:

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MAP ID: Draft

February 25, 1997

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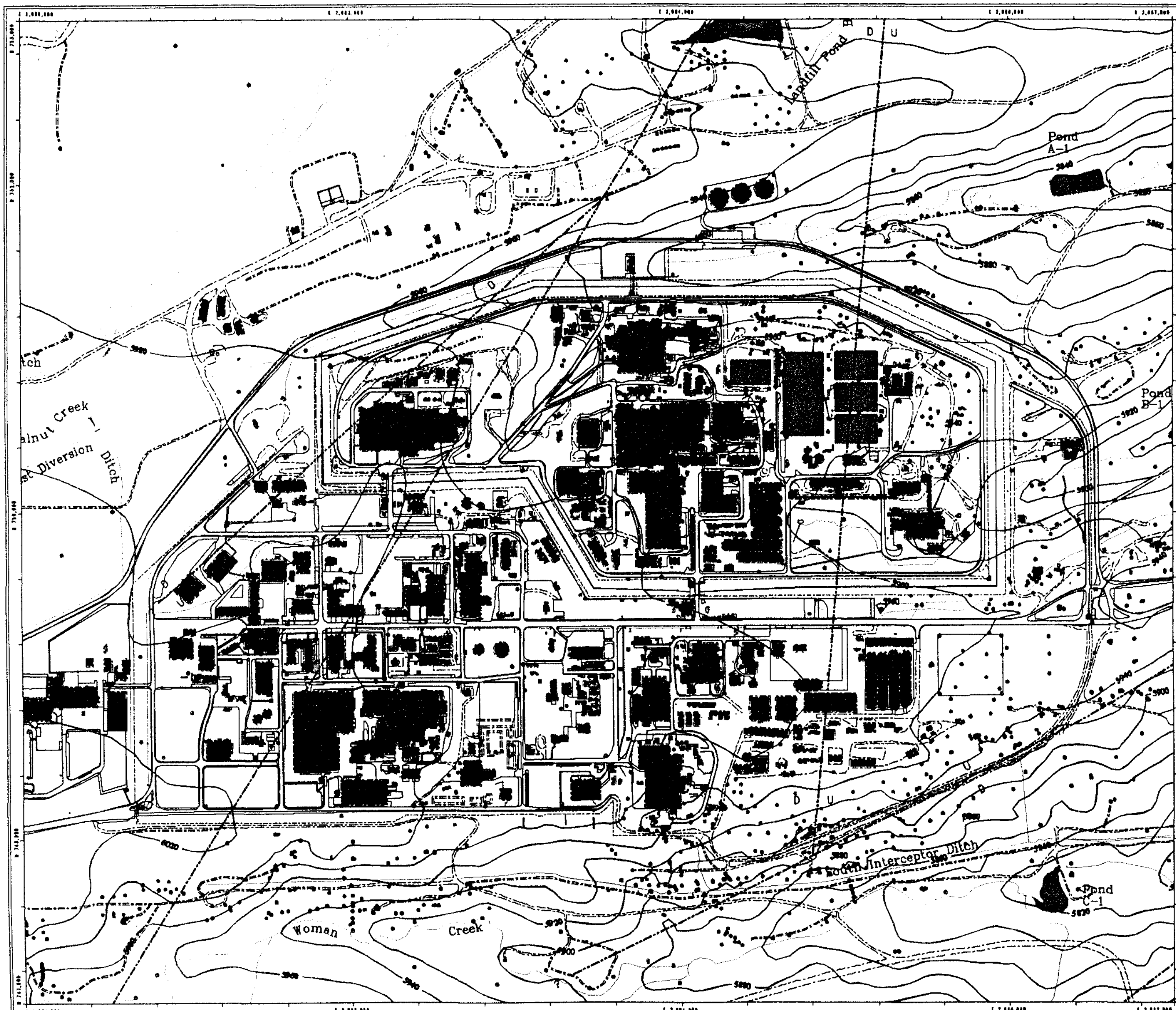

Figure 4
Structure Base of Alluvium

EXPLANATION

- Structure base of alluvium (top of bedrock elevation)
- Fault line - dashed where inferred
- Groundwater wells
- Boreholes

Standard Map Features

- Buildings or other structures
- Lakes and ponds
- Streams, ditches, or other drainage features
- Fences
- Rocky Flats boundary
- Paved roads
- Dirt roads
- Dirt Roads
- Trails

DATA SOURCE:
Buildings, roads, and fences provided by Facilities Engr. EG&G Rocky Flats, Inc. - 1991.
Hydrology provided by USGS - (date unknown)

Scale = 1 : 10380
1 inch represents approximately 863 feet

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

U.S. Department of Energy
Rocky Flats Environmental Technology Site

Prepared by:
RMRS Rocky Mountain Remediation Services, L.L.C.

MAP ID: Draft

February 28, 1997

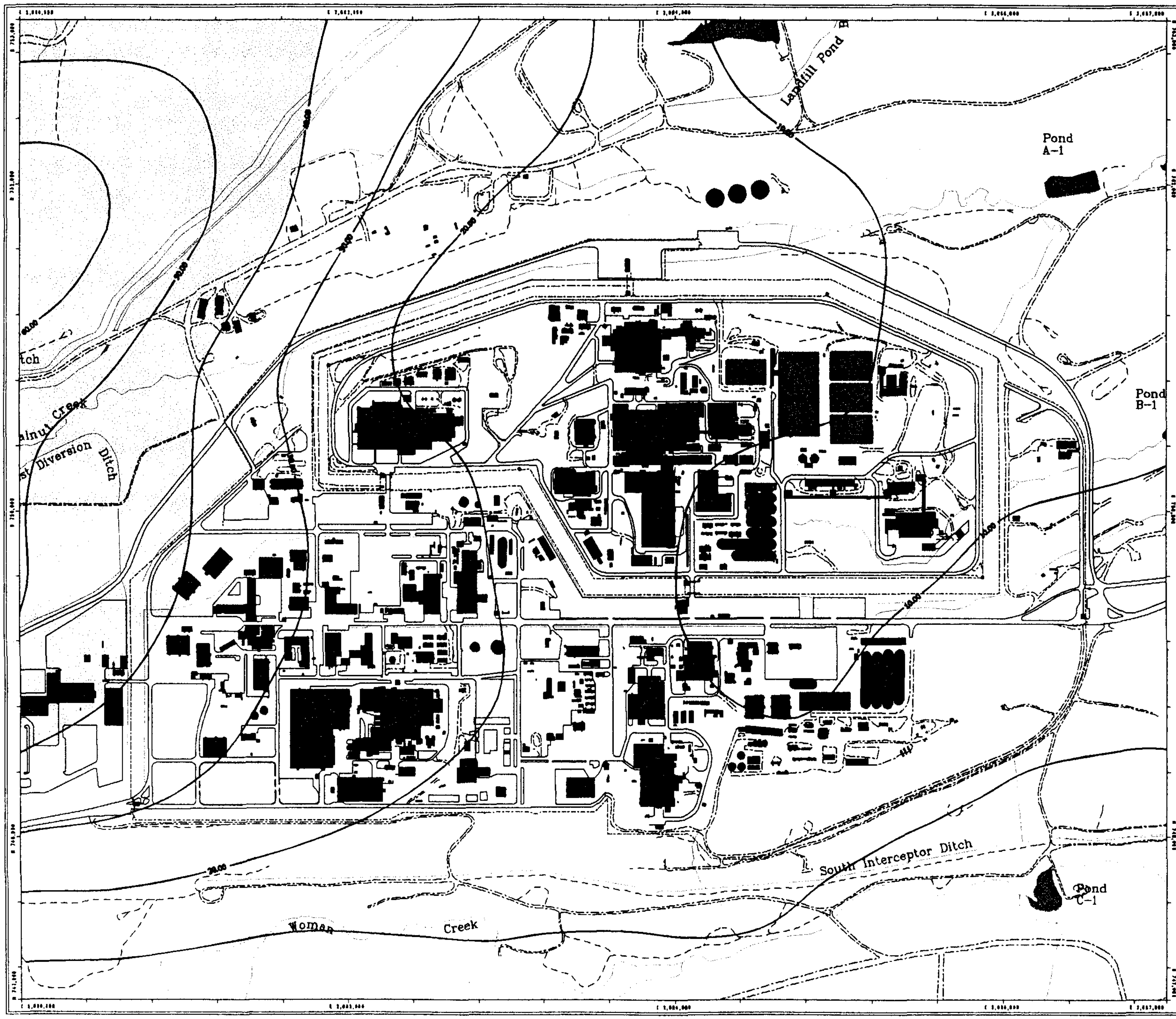

Figure 5
Thickness of Alluvium

EXPLANATION

Thickness of alluvium

Alluvium thickness greater than or equal to 40 Ft.

NOTE:
Potential economic thickness is 40 feet plus

Standard Map Features

Buildings or other structures

Lakes and ponds

Streams, ditches, or other drainage features

Fence

Rocky Flats boundary

Paved roads

Dirt Roads

Trails

DATA SOURCE:
Buildings, roads, and fences provided by Facilities Engr.
EG&G Rocky Flats, Inc. - 1997.
Hydrology provided by USGS - (date unknown)

Scale - 1 : 10360
1 inch represents approximately 863 feet

200 0 400 800ft

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

U.S. Department of Energy
Rocky Flats Environmental Technology Site

Prepared by:
RMRS Rocky Mountain Remediation Services, L.L.C.

MAP ID: Draft

February 25, 1997

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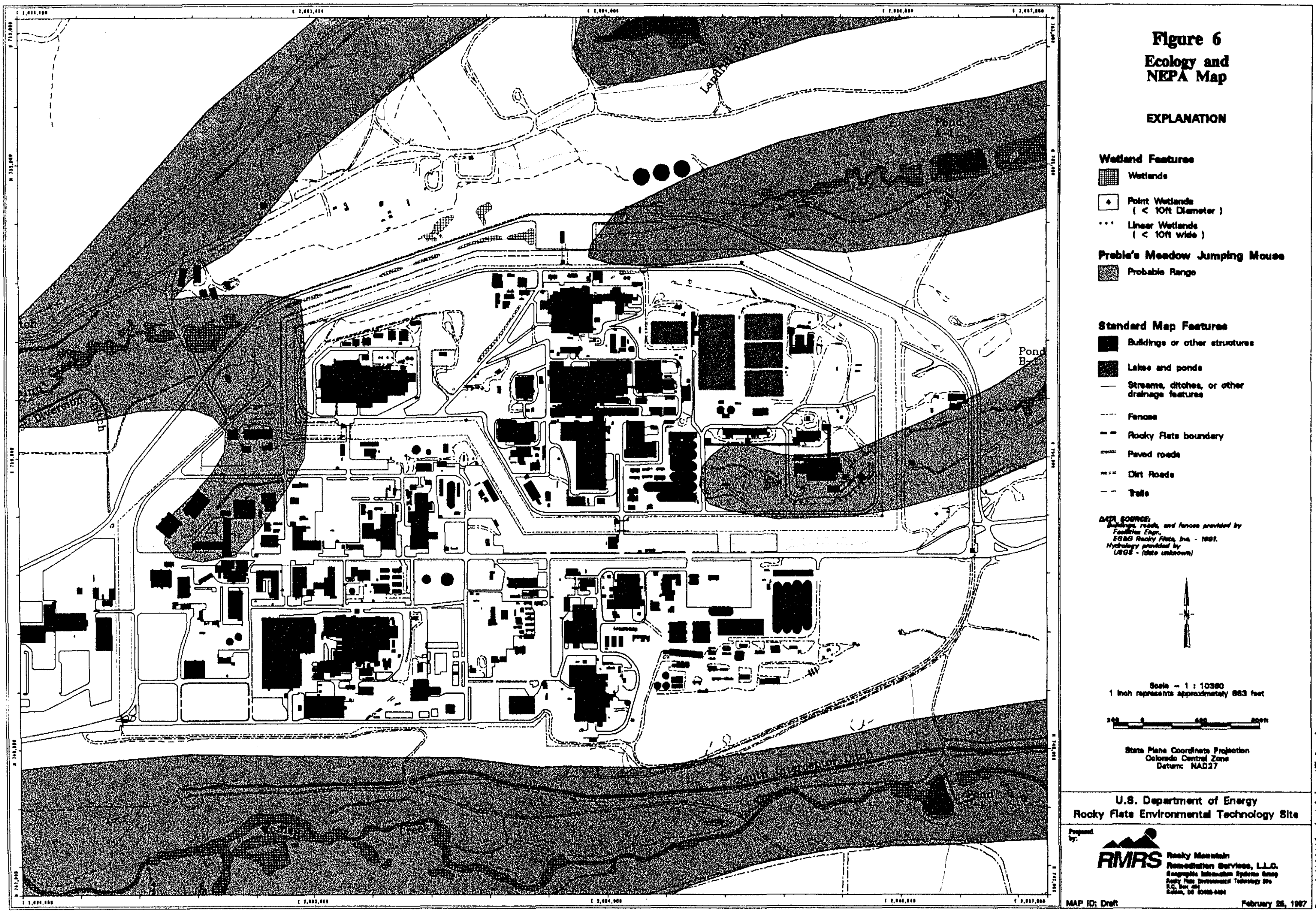

Figure 6
Ecology and NEPA Map
EXPLANATION
Wetland Features
Wetlands
Point Wetlands (< 10ft Diameter)
Linear Wetlands (< 10ft wide)
Preble's Meadow Jumping Mouse
Probable Range
Standard Map Features
Buildings or other structures
Lakes and ponds
Streams, ditches, or other drainage features
Fences
Rocky Flats boundary
Paved roads
Dirt Roads
Trails
DATA SOURCE:
Buildings, roads, and fences provided by Facilities Engr., EG&G Rocky Flats, Inc. - 1991.
Hydrology provided by USGS - (date unknown)
N
Scale = 1 : 10380
1 inch represents approximately 863 feet
State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27
U.S. Department of Energy
Rocky Flats Environmental Technology Site
Prepared by:
RMRS
Rocky Mountain Remediation Services, L.L.C.
MAP ID: Draft
February 26, 1997
Pond
Pond
South Interceptor Ditch
Landfill
Ditch

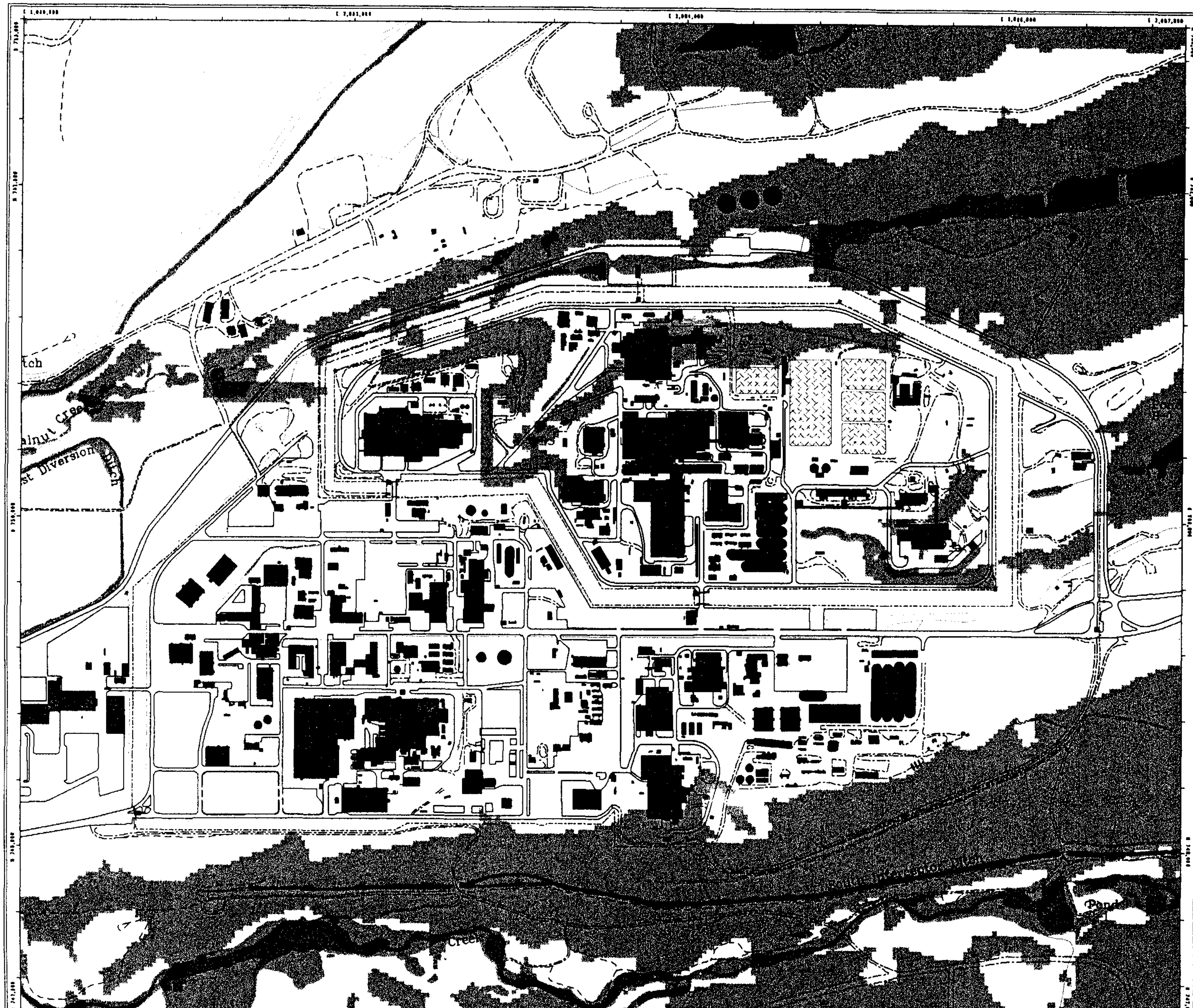

Figure 7
Adverse (for RWSF siting) Conditions Map

EXPLANATION

NOTE:
This map was created using the analytical capabilities of ARC/INFO. Three data layers (coverage's) were combined, representing physical restraining criteria, each given an equal weighting factor: wetlands, 100-year floodplain, and slopes greater than 15%. The surface was color coded based on the number of criteria present.
Point and line wetland features have a 50 foot buffer around them for better visibility.

- Lands best suited for the placement of a Waste Management Facility, based on criteria stated above
- One criterion present
- Two criteria present
- Three criteria present (least suitable location)

Standard Map Features

- Buildings or other structures
- Lakes and ponds
- Streams, ditches, or other drainage features
- Fences
- Rocky Flats boundary
- Paved roads
- Dirt Roads
- Trails

N

Scale = 1 : 10360
1 inch represents approximately 863 feet

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

U.S. Department of Energy
Rocky Flats Environmental Technology Site

Prepared by:
RMRS Rocky Mountain Remediation Services, L.L.C.
Geographic Information Systems Group

MAP ID: x7707

February 26, 1997

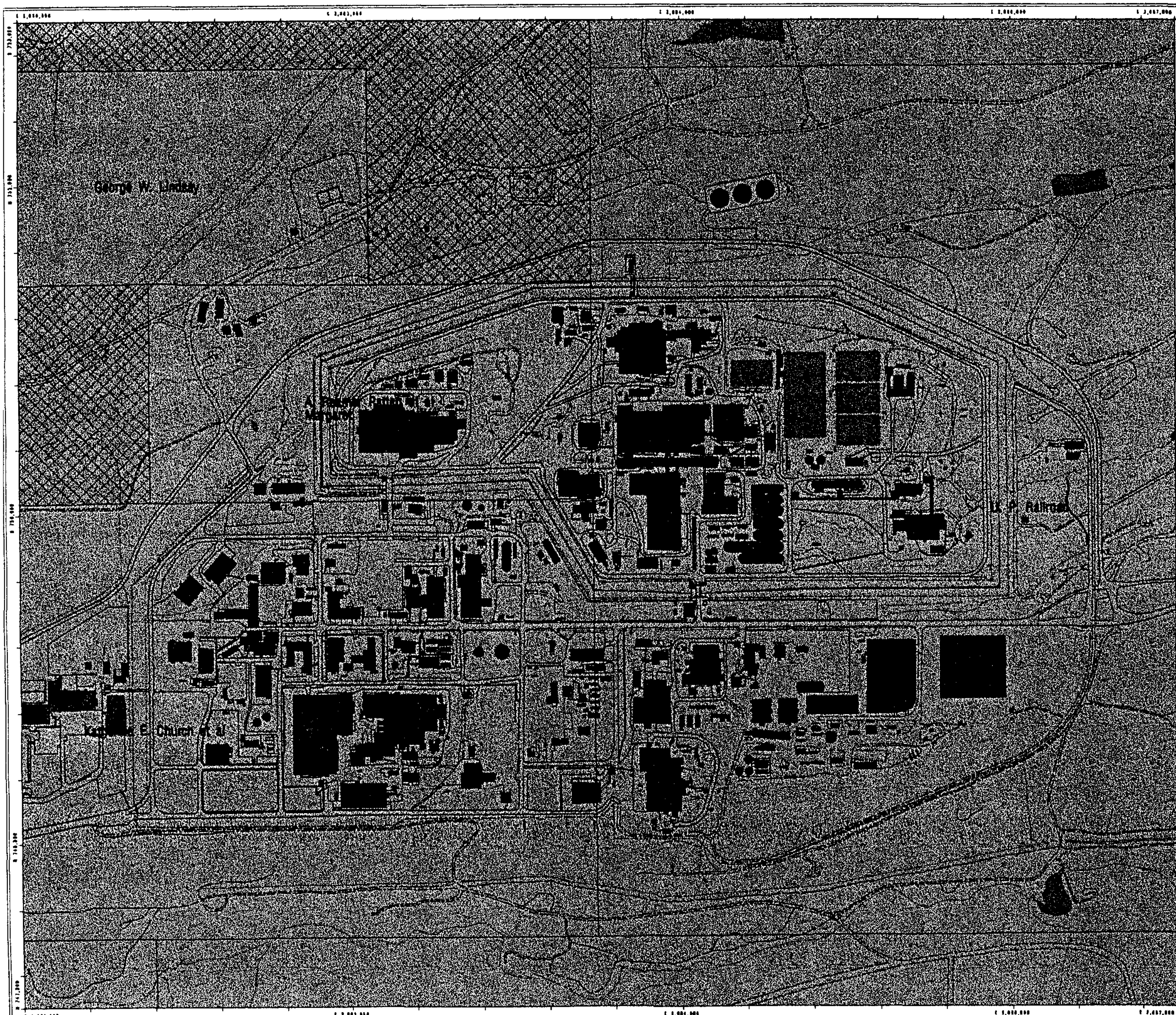

Figure 8
Mineral Ownership Map

EXPLANATION

- Private
- Government
- Both Government and Private

Standard Map Features

- Buildings or other structures
- Lakes and ponds
- Streams, ditches, or other drainage features
- Fences
- Rocky Flats boundary
- Paved roads
- Dirt Roads
- Trails

DATA SOURCES:
Buildings, roads, and fences provided by Facilities Engr., EG&G Rocky Flats, Inc. - 1991.
Hydrology provided by USGS - (date unknown)

Scale = 1 : 10360
1 inch represents approximately 863 feet

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

U.S. Department of Energy
Rocky Flats Environmental Technology Site

Prepared by:
RMRS
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Golden, CO 80402-0464

MAP ID: Draft

February 26, 1997

/home/sd12880/projects/edmassfig8.aml

D.1 SCREENING CRITERIA

The criteria used in the Onsite Remediation Waste Storage Facility Siting Study and the facility design screen is presented in Table D-1.

Table D-1 Screening Criteria for IM/IRA Remediation Waste Storage Facility

IM/IRA Selection Criteria	Siting Criteria	Design Criteria
1. CAMU CRITERIA - Ability to designate as CAMU per 6 CCR 1007-3 264.552 (c)		
(1.1) The CAMU shall facilitate the implementation of reliable, effective, protective, and cost-effective remedies.	X	X
(1.2) Waste management activities associated with the CAMU shall not create unacceptable risks to humans or the environment resulting from exposures to hazardous waste or hazardous constituents.	X	X
(1.3) The CAMU shall include uncontaminated areas of the facility only if the inclusion of such areas for the purpose of managing remediation waste is more protective than management of wastes at contaminated areas of the facility.	X	
(1.4) Areas within the CAMU where remediation wastes remain in place after closure of the CAMU shall be managed and contained to control, minimize, or eliminate future releases to the extent necessary to protect human health and the environment.	X	X
(1.5) The CAMU shall expedite the timing of remedial activity implementation, unless to do so would be inconsistent with 6 CCR 1007-3, 264.552(c)(1) or (c)(2).	X	X
(1.6) The CAMU shall minimize the land area of the facility upon which remediation wastes will remain in place after closure of the CAMU, unless to do so would be inconsistent with 6 CCR 1007-3, 264.522 (c)(1) or (c)(2).		X
(1.7) The CAMU shall enable the use, when appropriate, of treatment technologies, including innovative technologies, to enhance the long-term effectiveness of remedial actions by reducing the toxicity, mobility, or volume of remedial waste.	X	
2. PUBLIC PROTECTION (GEOTECHNICAL AND HYDROLOGICAL CRITERIA) - Ability to protect public based on criteria in 6 CCR 1007-2 Part 2		
(2.1) The geological and hydrogeologic conditions of a location in which hazardous waste is to be stored should be such that reasonable assurance is provided that the wastes are isolated within the storage area away from pathways to the public.	X	X
(2.2) Geomorphic conditions either will not vary significantly from the present state or will occur to a predictable degree, which can be accommodated in the facility design.	X	
(2.3) Structural-related issues include slope and geotechnical stability.	X	X
(2.4) The immediate area of the location should be in strata of minimal groundwater flow.	X	
(2.5) Geological strata combined with engineering barriers shall provide minimum permeability	X	X
(2.6) Siting consideration should include bedrock and surface integration including the nature and extent of bedrock material.	X	

Table D-1 (continued)

IM/IRA Selection Criteria	Siting	Design
(2.7) Siting consideration should include minimal relative presence of fractures or faults.	X	
(2.8) Consideration should be given to the relative depth to bedrock and groundwater, including seasonal fluctuations for groundwater.	X	
(2.9) The Site will not impact nor be impacted by surface water.	X	
(2.10) Relative distance to nearest discharge area shall include consideration of groundwater flow direction and travel time.	X	X
(2.11) The terrain is such that good drainage exists for movement of precipitation away from the storage area, and such that water and wind erosion will be minimal.	X	X
3. SITE SPECIAL ISSUES, supports the timely construction of a facility and integration with other Site programs, including the Site Vision to occur. (schedule criteria)		
(3.1) Ability of the site to support the Site Vision and RFCA objectives.	X	X
(3.2) Impacts from existing utility, sewer, process waste, or communications lines.	X	X
(3.3) Impacts from security.	X	X
(3.4) Impacts from plutonium consolidation or residue stabilization activities.	X	
(3.5) Impacts from building deactivation activities.	X	
(3.6) Impacts from decommissioning activities	X	
(3.7) Impacts from current RCRA units	X	X
(3.8) Impacts from mineral rights issues or other easements	X	
(3.9) Ability to collocate additional RWSFs in the same vicinity	X	X
4. COST CRITERIA		
(4.1) *Cost of engineering and construction of protective measures* (includes construction, preconstruction, and design costs)	X	X
(4.2) Cost of location preparation including building demolition, subsurface utility line removal and rerouting, access requirements, and power/facility requirements above the basic RWSF	X	X
(4.3) Cost of cap, monitoring, and closure		X
(4.4) Total Life-Cycle Cost		X
5. REGULATORY SUPPORT - State Principles for On-Site Disposal of Contaminated Materials (27-February-95 letter from Tom Looby to Jack McGraw and Mark Silverman) (Although these criteria were intended to be applied to disposal faciility, they also provide a reasonable basis for regulatory support in evaluating siting and design alternatives.)		
(5.1) The number of disposal sites must be minimized. We (Colorado Department of Public Health and the Environment) suggest one centralized site be chosen for consolidation of contaminated materials.	X	
(5.2) Every effort should be made to site a centralized disposal facility in an area of optimal geologic parameters preferably within, or close to the IA.	X	
(5.3) Any disposal facility must be designed and built as a state-of-the-art disposal facility *that meets or exceeds all permitting and regulatory requirements.* This includes (but not limited to) siting, design, long-term protection, and performance requirements.	X	X

Table D-1 (continued)

IM/IRA Selection Criteria		Siting	Design
	(5.4) A permitted centralized disposal facility provides DOE the greatest degree of future applicability and utility. As such, we believe that a centralized disposal facility should be designed with the intent to permit it from a RCRA/CHWA perspective.	X	X
	(5.5) Levels of radioactive contamination in any materials disposed on-site will be limited....		X
	(5.6) Any disposal location at RFETS should be located in areas that have limited future land use potential and will be controlled by DOE until the interred waste no longer presents a risk to human health or the environment	X	
6.	OTHER STAKEHOLDER CONCERNS		
	(6.1) General public perception and acceptance	X	X
	(6.2) Municipal or County acceptance.	X	X
	(6.3) DOE Orders	X	X
	(6.4) NEPA	X	
	(6.5) Air Impacts	X	X
	(6.6) Compliance to ARARS	X	X
	(6.7) Long Term Liability and Effectiveness		X
	(6.8) Ability to Accept Waste		X
	(6.9) Demonstrated Performance and Useful Life		X
	(6.10) Construction and Operation		X
	(6.11) Schedule Requirements		X
	(6.12) Availability of Technology		X
	(6.13) Availability of Service and Materials		X

The stakeholder concerns criteria addresses impacts to parties affected by decisions at the Site and to the Site and the surrounding community, as follows:

6.1) **General Public Perception/Acceptance** - The public sentiment including the general public and concerned local communities is evaluated as an alternative.

6.2) **Municipal and County Acceptance** - The viewpoints of local government including Jefferson County and local municipal governments are reflected in this criteria.

6.3) **DOE Orders** - This criteria has the ability to meet the requirements of DOE orders, particularly orders that protect the safety of workers, the public, and the environment.

6.4) **NEPA** - This criteria contains NEPA compliance requirements including environmental impacts, socioeconomic impacts, and impacts to archeological, cultural, and historical locations.

6.5) **Air Impacts** - This criteria includes impacts to air quality—onsite, offsite and regionally, as well as air pollution prevention or mitigative measures.

6.6) **Compliance to Performance Regulations** - This criterion was used to evaluate the ability of any given alternative to meet existing and potential state and Federal performance requirements. This did not include any performance requirements specific to the cleanup of Individual Hazardous Substance Sites that are independent of any given alternative.

6.7) **Long-Term Liability and Effectiveness** - This criterion was employed to evaluate the ability to safely isolate, contain, and manage remediation waste. It also addressed the issues of long-term liability, particularly for alternatives whose ability to safely manage materials could be subject to change in the future.

6.8) **Ability to Accept Waste** - This criterion was utilized to evaluate the ability of an alternative to accept waste volumes and different types of waste that will result from environmental restoration activities. This included, at a minimum, the ability of various options to accept remediation waste at the same rate that it is generated and to have the overall capacity to be a viable solution for at least near-term activities.

6.9) **Demonstrated Performance/Useful Life** - This criterion was used to address the viability and durability of a selected alternative.

6.10) **Construction and Operation** - This criterion was used to evaluate a number of factors such as whether monitoring is feasible during operations, whether environmental and geological features would circumvent construction or the overall constructability, and whether transportation of remediation waste is feasible.

6.11) **Schedule Requirements** - This criterion was used to directly support one of the main objectives of this IM/IRA—can the alternative be ready to accept remediation waste and be fully operational when needed in the future.

6.12) **Availability of Technology** - This criterion was employed to evaluate whether the technologies exist and have been developed to the point where they would be available. This was primarily directed at design considerations; however, the availability of monitoring, transportation, handling, and safety technologies was also part of this consideration.

6.13) **Availability of Services and Materials** - This was an evaluation of the availability of construction materials, equipment, analytical support, construction labor, and support personnel over the entire life of any given alternative.

D.2 COMPARISON OF ALTERNATIVES CRITERIA

The final comparison of alternatives used the nine CERCLA criteria defined in 40 CFR Part 300.430, that are summarized, as follows:

1) **Overall Protection of Human Health and the Environment** - This criterion was used to evaluate the alternative's impacts to ground water, surface water, drainage pattern impact, soil, air, plants and animals for the life cycle of the IM/IRA. Emphasis is placed on the ability of the alternative to control migration and leachability of contaminants and impact of any construction.

   Impacts on erosion rate and loss of top soil were also examined including their offsite effects of erosion and wind blown soil. Alternatives were evaluated as to whether there were temporary or short-term changes to the soil and the erosion rate or whether these changes had lasting long-term impacts. The ability of an alternative to minimize and/or mitigate these erosional effects through erosion control or replacement of the topsoil was evaluated.

   Each alternative was analyzed for biological impacts, direct and indirect impacts on critical habitat, wetlands, and vegetation. Analyzing biological effects included the cumulative effects of regionally important species, endangered species, and biodiversity. It also included the irreversible effects of permanent loss of habitat and permanent loss of species. The ability to restore biological habitat and wetlands or reduce the impact by the timing of the action was also evaluated.

   Impact to air quality onsite, offsite, and regionally; and pollution prevention or mitigative measures were also considered.

   The impact of the alternative on the safety of the surrounding community is evaluated. This includes not only storage of remediation waste but also the impact of transportation of remediation waste. Direct effects on water quality and water consumption are an important part of this criteria as well as airborne materials that could potentially impact public health.

   The health and safety of workers is evaluated. This includes all phases of the alternative from construction to all handling and operation to closure and surveillance.

2) **Compliance with Performance Regulations** - This criterion was used to evaluate the ability of any given alternative to meet existing and potential state and Federal performance requirements. This did not include any performance requirements specific to the cleanup of Individual Hazardous Substance Sites that are independent of any given alternative. However, it does include CAMU criteria per 6 CCR 1007-3 264.552 (c).

3) **Long-Term Effectiveness and Permanence** - This criterion was used to evaluate the ability to safely isolate, contain, and manage remediation waste with the passage of time. It also addressed the issues of long-term liability, particularly for alternatives whose ability to safely manage materials could be subject to change in the future.

4) **Reduction of Toxicity, Mobility or Volume Through Treatment** - This criterion was used to evaluate the ability for each option to reduce the toxicity of the waste as well as its mobility and overall volume through treatment.

5) **Short-Term Effectiveness** - This is a gauge of the alternative's capability to support upcoming risk reduction efforts at the Site. These efforts are primarily early actions which could include hot-spot removal, tank removals, additional solar pond remediation, and PCB location remediation.

6) **Implementability** - This criterion was used to look at the alternatives from a technical feasibility standpoint as well as an availability standpoint. It compares the ability of the alternatives to accept waste, their demonstrated performance and useful life, construction and operation considerations, the options ability to meet schedule requirements, the availability of the selected technology, and the availability of services and materials for each option.

7) **Cost** - The total cost of each alternative was evaluated, as were individual costs for design, site preparation, construction, operations, capping, monitoring, and final closure.

8) **State Acceptance** - This criterion was used to reflect the viewpoints of the state government including Jefferson County and local municipal governments. This is a modifying criterion that will reflect input from the Colorado Department of Public Health and Environment as part of the review process, Statements addressing this criterion in the draft text serve only as placeholders until actual comments are received.

9) **Community Acceptance** - This criterion was used to evaluate the public sentiment concerning an alternative. It includes the general public as well as concerned local communities. This is a modifying criterion that will address public comments as part of the review process. Statements addressing this criterion in the draft text serve only as placeholders until actual comments are received.

Appendix E

Descriptions of Remediation Waste Storage Facility Design Alternatives

Table of Contents

REMEDIATION WASTE STORAGE FACILITY (RWSF) DESIGN ALTERNATIVES

Introduction

The alternative facility designs were all based on the need to accommodate 100,000 cubic yards (cy), with the ability to expand to 300,000 cubic yards if required, for Low Level Mixed Waste (LLMW), Low Level (LL), or Hazardous Wastes (HW) in a storage facility. None of the designs considered were tailored to a specific location on RFETS site. In general, bulk waste placement requires the smallest land area when compared to containerized waste placement.

Attributes common to alternative designs:

- 100,000 to 300,000 cubic yards waste capacity if required for retrievable, monitored, storage.
- Each design considered would place the waste above the present grade.
- Each design was considered to be capable of waste retrieval, although the ease (and cost) of retrievability varied significantly among the designs.
- Conceptual design sketches (Figures) and cost estimates (Tables) follow the description of each design.
- Any leachate collected would be treated at an existing onsite facility. Since these facilities would remain in operation during the operation of the storage cell additional operating costs to treat the leachate are negligible were not included in this estimate.
- Groundwater monitoring wells would be installed both hydraulically up gradient and down gradient of the facility and operated from start of construction through the end of post closure monitoring.
- Costs were escalated to reflect estimated actuals at the time of expenditure, based on DOE guidance documented in RFETS 1996 Budget Call Manual.
- Construction periods were assumed to be of one year duration for all alternatives.
- Operations costs were defined as those activities directly related to placement of (prepared) waste into each alternative facility.

- Treatment and handling systems are not expected to produce emissions sufficient to require additional permitting. Air monitoring will be conducted per applicable state requirements via the existing Site monitoring system. Any additional air monitoring required for worker Health and Safety consideration will be monitored by the appropriate oversight organizations.

Abovegrade Storage Cell

This RWSF is designed such that clean dirt (fill) would be used to construct the sides of the cell so that the entire facility would be above the present grade. The design is similar to a standard Subtitle "C" landfill in use throughout the United States. The whole cell is placed at a higher elevation to allow greater vertical separation between the bottom of the cell and the water table. The conceptual design cost estimate assumed that the remediation waste would be placed in the cell without containers (in bulk, compacted in place), however, some existing containerized waste could be placed. In addition, the placement of individual waste streams would be mapped and gridded to allow retrieval (by excavation) when desired.

- This waste cell design includes a double liner with leachate collection system. These features were used to develop the cost estimate and may change during detailed design (see Figures E-1 and E-2). Compliance with 6 CCR 1007-3 Part 264 Subpart N requirements is accomplished by the following provisions:

  - A cover system that meets the intent of the design requirements for covers in 6 CCR 1007-3 Part 264 Subpart N recognizing the limited operational life of 25 years.

  - Leachate collection layer consisting of one foot of drainage gravel

  - Primary liner would be composed of an 80 mil geomembrane

  - The leak detection system includes a geocomposite (e.g., A geonet with a geotextile on each side). All components of the leak detection system must be chemically resistant to the waste and the leachate per the requirements of 6 CCR 1007-3 Part 264 Subpart N.

  - Secondary liner would include three feet of compacted clay, overlain by a 80 mil geomembrane. All components of the secondary liner system must be chemically resistant to the waste and the leachate per the requirements of 6 CCR 1007-3 Part 264 Subpart N.

- This cell design cost estimate was based on cell dimensions of 440 feet long, 360 feet wide, and 30 feet deep. Table E-1 presents the cost estimate summary. The cost estimate included a clean dirt cover installed over exposed waste at the close of daily placement operations to prevent wind dispersion of the waste.

  - The entire footprint including side slopes cover approximately 9 acres.

— Cell Support Facilities include a lay down area for cell construction materials.

— Any leachate collected would be treated at an existing onsite facility such as the 374 evaporator, the 910 evaporator, or the 891 treatment building. The costs for treatment and storage of the leachate has been incorporated into the cost estimates.

— Groundwater monitoring wells (3 each) will be installed both hydraulically up gradient and down gradient and will be operated from start of construction through the end of post closure monitoring.

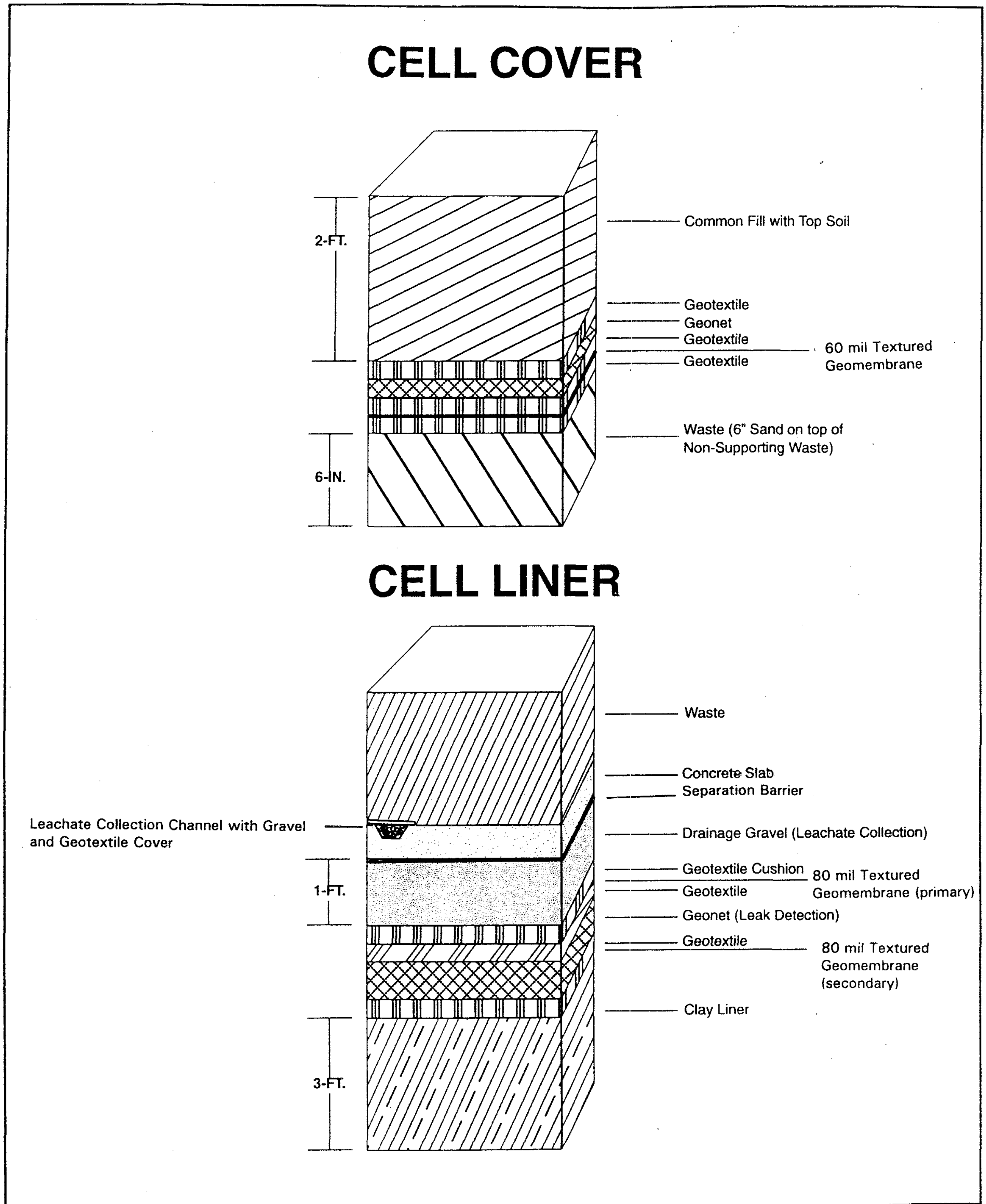

Figure E-1

ON-SITE FACILITY CROSS SECTION

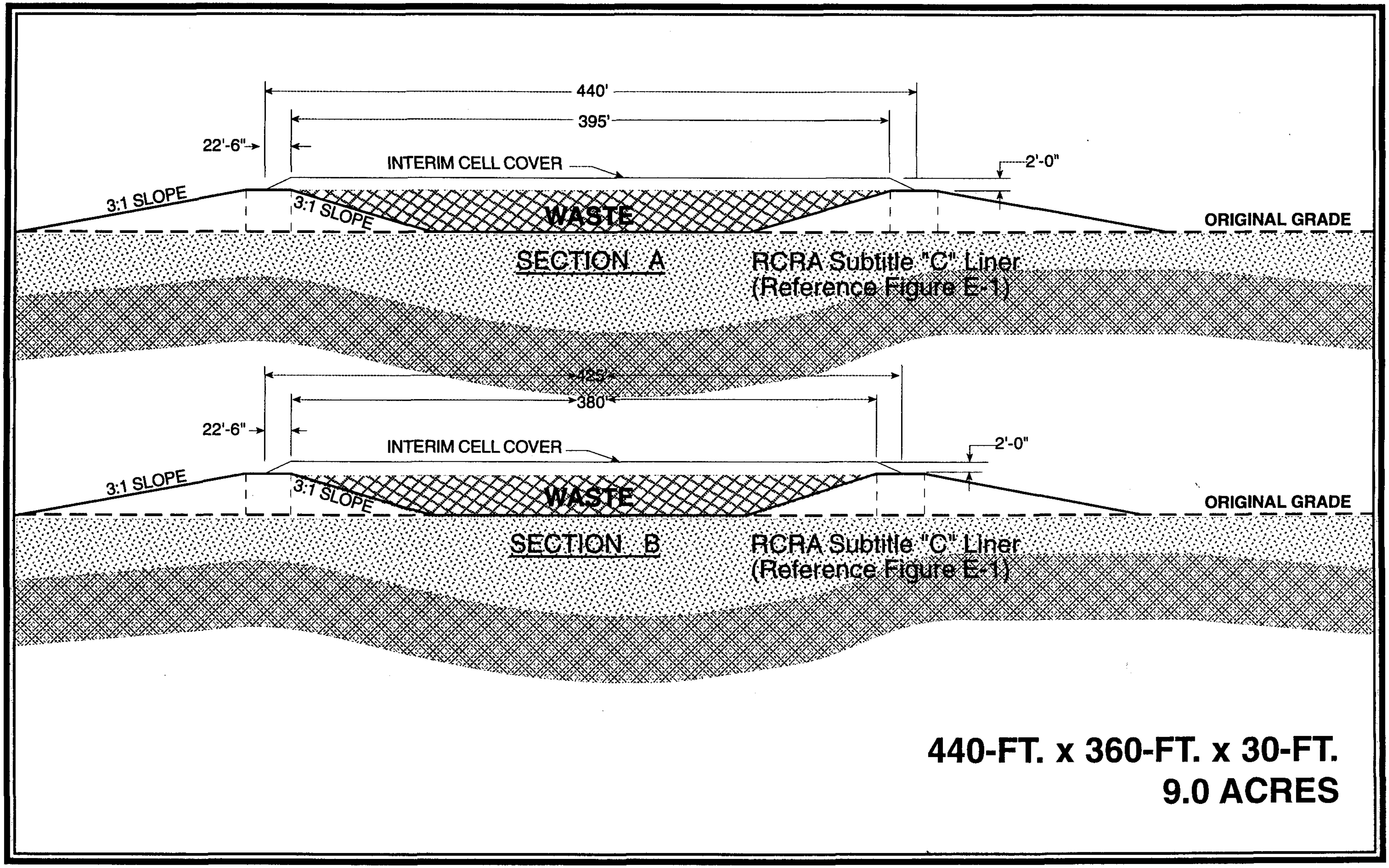

Figure E-2

CROSS-SECTION OF ABOVE-GRADE STORAGE CELL

TABLE E-1

Abovegrade Storage Cell

Task Description	Estimated Cost
Containers	$0
Packaging	$2,100,000
Characterization	$5,800,000
Transportation	$2,300,000
Design	$2,200,000
Permitting	$300,000
Pre-Construction	$400,000
Site Preparation	$8,800,000
Construction	$41,700,000
Operations	$9,000,000
Cap Installation	$5,300,000
Monitoring	$13,900,000
Final Closure	$400,000
Off-Site Disposal	N/A
Contingency	$27,000,000
Total Life Cycle Costs	*$119,200,000*

Note:
Total life cycle costs do not include offsite disposal costs. These costs would include transportation and disposal costs and would add over $150 million dollars to the total cost.

Concrete Lined Cell, with Bulk Placement

This alternative design consists of three adjacent open top concrete cell(s) placed over a (RCRA Subtitle 'C' landfill) double liner and leachate collection system (see Figure E-3A). When the cell(s) are filled with remediation waste an cover is placed over the facility. The conceptual design cost estimate assumed that the remediation waste would be placed in the cell without containers (in bulk, compacted in place), however, some of the waste could be placed in containers, in addition, the placement of individual waste streams would be mapped to allow retrieval (by excavation) when desired. The individual cells are modular and would be constructed as needed over the liner to allow flexibility in sizing the facility.

The concept for the design was modified from the BNFL Drigg Facility in the United Kingdom. The following features were used to develop the cost estimate and may change during detailed design.

- This waste cell design includes an cover (that complies with 6 CCR 1007-3 Part 264 Subpart N(see Figure E-1). The surface slope of the finished cover would be approximately 4%. Should a long-term cover ever be installed it too would comply with 6 CCR 1007-3 Part 264 Subpart N.

- This waste cell design also includes a double liner with leachate collection system (see Figure E-1). Compliance with 6 CCR 1007-3 Part 264 Subpart N requirements is accomplished by the following provisions:

  — A cover system that meets the intent of the design requirements for covers in 6 CCR 1007-3 Part 264 Subpart N recognizing the limited operational life of 25 years.

  — Self supporting open top concrete shell with reinforced concrete walls and floor slab. The wall design incorporates integral water stops and the floor design incorporates cast-in-place drain channels and sumps as part of leachate collection system. These channels will be filled with gravel and covered with a geotextile to prevent soil from getting into the collection system. The leachate will be conveyed by gravity flow to a collection sump. This is a separate collection system form the collection system beneath the floor slab; however, both systems share the same sump.

  — Leachate collection layer consisting of one foot of drainage gravel. A separation barrier will separate the floor slab from the gravel and keep concrete from filling in the gravel when the floor slab is poured. The leachate will collect in a sump and pumps will be used to transfer the leachate to tank . The leachate tank will be used for temporary storage until the leachate is transferred to the onsite treatment facility.

the permeability of the leachate collection system must meet all of the Subpart N requirements.

— Primary liner would be composed of an 80 mil geomembrane chemical resistant to the waste and leachate as required by 6 CCR 1007-3 Part 264 Subpart N.

— The leak detection system includes a geocomposite (e.g., A geonet with a geotextile on each side). All components of the leak detection system must be chemically resistant to the waste and the leachate per the requirements of 6 CCR 1007-3 Part 264 Subpart N.

— The Secondary liner would include three feet of compacted clay, overlain by a 80 mil geomembrane. All components of the secondary liner system must be chemically resistant to the waste and the leachate per the requirements of 6 CCR 1007-3 Part 264 Subpart N. Two feet of soil or bales of hay will be placed on the concrete temporarily until waste is placed the facility to provide frost protection.

- The Concrete Lined Cell facility conceptual design includes the following features which were included for cost estimating purposes (see Table E-2 for the cost estimate summary).

  — Facility size of 500 feet long by 360 feet wide by approximately 14 feet deep

  — The temporary storage facility long term footprint would be approximately four acres

  — The entire footprint during construction and placement operations would be approximately 10 acres (cell area + lay down areas + operations areas = 10 acres)

  — No aisles or corridors.

  — Three open top concrete modules

  — A lay down area for cell construction materials

  — Groundwater monitoring wells (3 each) will be installed both hydraulically up gradient and down gradient and will be operated from start of construction through the end of post closure monitoring

— Any leachate collected would be treated at an existing onsite facility such as the 374 evaporator, the 910 evaporator, or the 891 treatment building. The costs for treatment and storage of the leachate has been incorporated into the cost estimates.

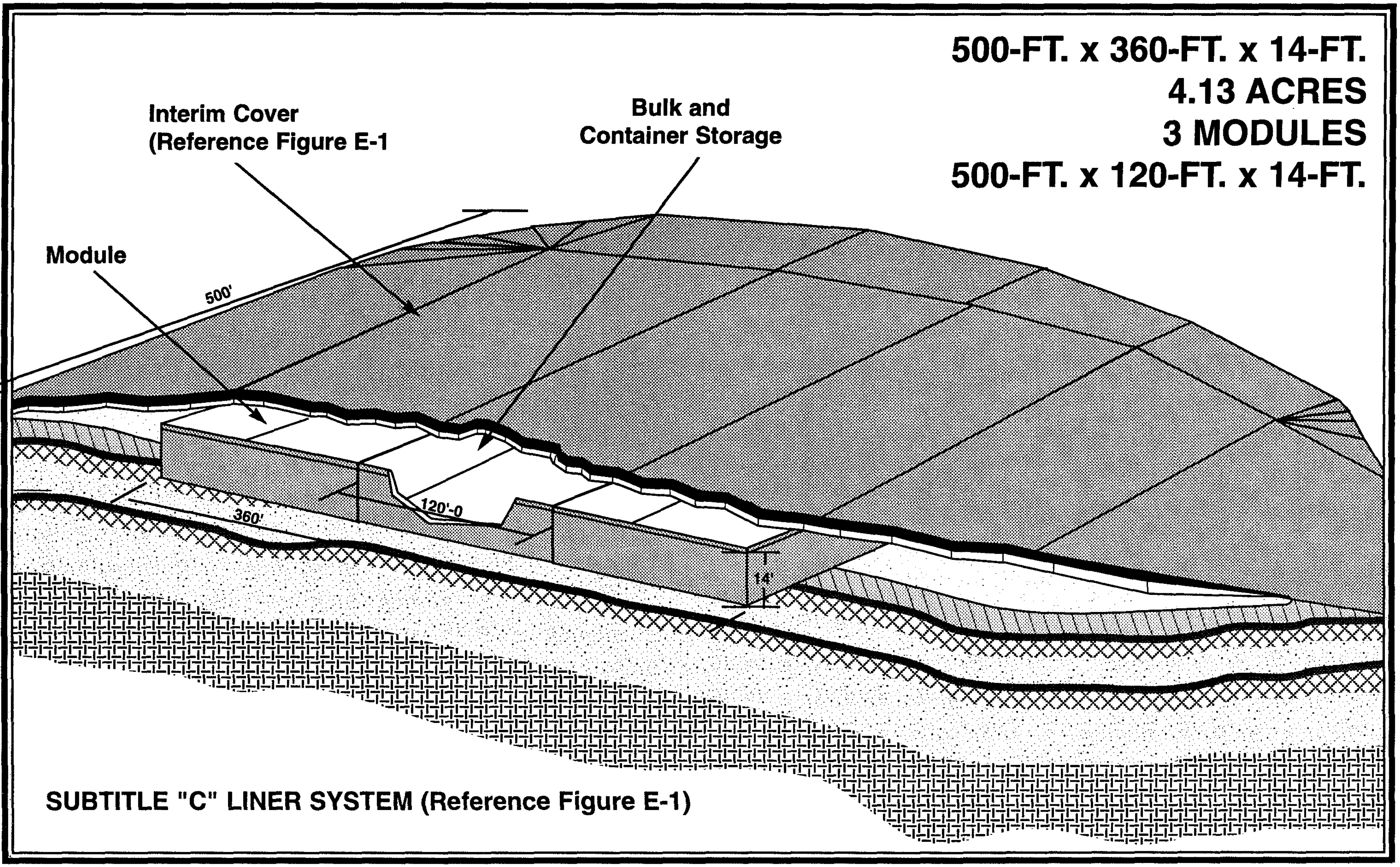

Figure E-3A

CONCRETE-LINED CELL WITH BULK WASTE PLACEMENT

TABLE E-2

Concrete Lined Cell with Bulk Waste Placement

Task Description	Estimated Cost
Containers	$0
Packaging	$2,100,000
Characterization	$5,800,000
Transportation	$2,300,000
Design	$1,600,000
Permitting	$300,000
Pre-Construction	$150,000
Site Preparation	$1,970,000
Construction	$18,600,000
Operations	$8,600,000
Cap Installation	$5,300,000
Monitoring	$13,000,000
Final Closure	$1,800,000
Off-Site Disposal	N/A
Contingency	$17,600,000
Total Life Cycle Costs	*$79,120,000*

Note:
Total life cycle costs do not include offsite disposal costs. These costs would include transportation and disposal costs and would add over $150 million dollars to the total cost.

Concrete Lined Cell in Containers

This alternative design consists of three adjacent open top concrete cell(s) placed over a (RCRA Subtitle 'C' landfill) double liner and leachate collection system (see Figure E-3B). When the cell(s) are filled with remediation waste an cover is placed over the facility. All of the remediation waste would be placed in containers (Cargo containers) which would then be placed into the cells. This aspect is the only significant difference from the previously described option "Concrete Lined Cell with Bulk Placement". Individual waste streams would be recorded and mapped to allow retrieval (by excavation) when required. The individual cells are modular and would be constructed as needed over the liner providing flexibility in sizing the facility. The concept for the design was modified from the Drigg Facility in the United Kingdom.

The following features were used to develop the cost estimate and may change during detailed design.

- This waste cell design includes an cover that complies with 6 CCR 1007-3 Part 264 Subpart N(see Figure E-1). The surface slope of the finished cover would be approximately 4%. Should a long-term cover ever be installed it too would comply with 6 CCR 1007-3 Part 264 Subpart N.

- This waste cell design also includes a double liner with leachate collection system (see Figure E-1). Compliance with 6 CCR 1007-3 Part 264 Subpart N requirements is accomplished by the following provisions:

    — A cover system that meets the intent of the design requirements for covers in 6 CCR 1007-3 Part 264 Subpart N recognizing the limited operational life of 25 years.

    — Self supporting open top concrete shell with reinforced concrete walls and floor slab. The wall design incorporates integral water stops and the floor design incorporates cast-in-place drain channels and sumps.

    — Leachate collection layer consisting of one foot of drainage gravel

    — Primary liner would be composed of an 80 mil geomembrane chemically resistant to the waste and leachate as required by 6 CCR 1007-3 Part 264 Subpart N.

    — The leak detection system includes a geocomposite (e.g., A geonet with a geotextile on each side). All components of the leak detection system must be chemically resistant to the waste and the leachate per the requirements of 6 CCR 1007-3 Part 264 Subpart N.

— Secondary liner would include three feet of compacted clay, overlain by a 80 mil geomembrane. All components of the secondary liner system must be chemically resistant to the waste and the leachate per the requirements of 6 CCR 1007-3 Part 264 Subpart N.

- The Concrete Lined Cell facility conceptual design includes the following features which were included for cost estimating purposes (see Table E-3 for the cost estimate summary).

  — Facility size of 405 feet wide by 500 feet long by approximately 14 feet deep

  — The waste cell facility long term footprint would be approximately 4.6 acres

  — The entire footprint during construction and placement operations would be approximately 10 acres (Cell area + Lay down areas + Operations areas = 10 acres)

  — No aisles or corridors

  — Three open top concrete modules

  — A lay down area for cell construction materials

  — Groundwater monitoring wells (3 each) will be installed both hydraulically up gradient and down gradient and will be operated from start of construction through the end of post closure monitoring

  — Any leachate collected would be treated at an existing onsite facility, and those costs were not included in the estimate such as the 374 evaporator, the 910 evaporator, or the 891 treatment building. The costs for treatment and storage of the leachate has been incorporated into the cost estimates.

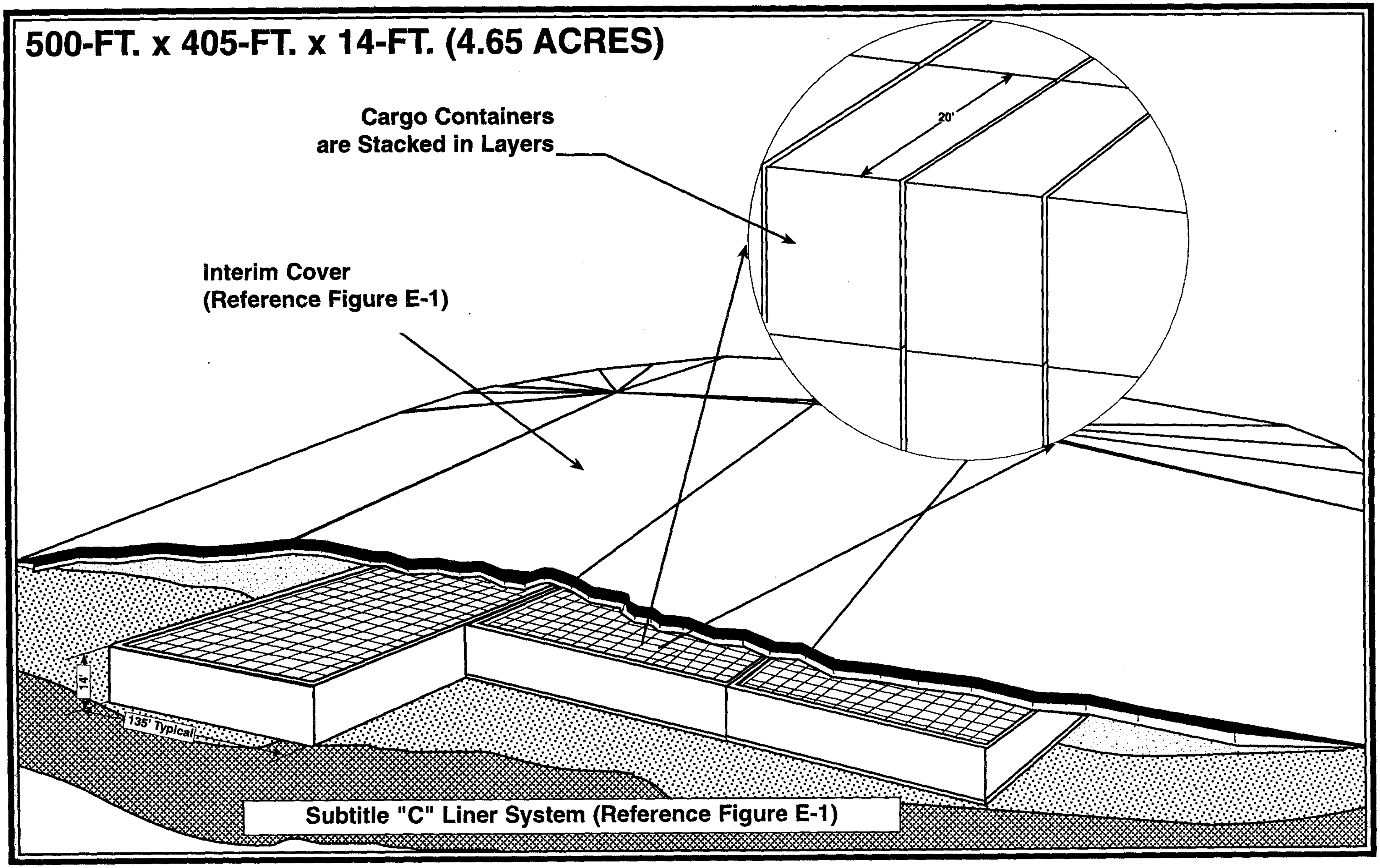

Figure E-3B

CONCRETE-LINED CELL IN CARGO CONTAINERS

TABLE E-3

Concrete Lined Cell in Containers

Task Description	Estimated Cost
Containers	$74,930,000
Packaging	$1,700,000
Characterization	$5,800,000
Transportation	$2,300,000
Design	$1,600,000
Permitting	$300,000
Pre-Construction	$150,000
Site Preparation	$1,970,000
Construction	$18,600,000
Operations	$4,900,000
Cap Installation	$5,300,000
Monitoring	$10,400,000
Final Closure	$1,800,000
Off-Site Disposal	N/A
Contingency	$37,700,000
Total Life Cycle Costs	*$167,450,000*

Note:
Total life cycle costs do not include offsite disposal costs. These costs would include transportation and disposal costs and would add over $150 million dollars to the total cost.

Hardened Concrete Vault

This alternative design would place cargo containers, filled with remediation waste, within an abovegrade concrete structure (see Figure E-4). The structure would be designed as a self supporting, free standing, abovegrade, weatherproof structure. This structure would be constructed over a double liner and leachate collection system. The structure would consist of three modules (Vaults). Each module would contain a double row of cargo containers with an access aisle between the rows. The cargo containers would be stacked in the vault by forklifts from the access aisle. At the close of waste placement operations, each cell would be capped with a concrete roof, then the structures comprising the facility would be covered with an cover. This design enhances the monitoring capability during placement operations and retrievability after closure due to the open aisles and identified waste in individual containers. The concept for the design was modified from the "E"-Area Vaults from the DOE Savannah River Complex.

During the period of post closure monitoring (or later) access could be made into the vaults (by excavating through the cover) to inspect or retrieve the waste containers via the aisles which were left open , but isolated from the environment when the vaults were closed.

- The following features were used to develop the cost estimate (see Table E-4) and may change during detailed design.

  - Facility size would be approximately 560 feet long, 450 feet wide, and 14 feet high and consist of three modules

  - One module could be constructed each year, for three years, (subject to the rate of remediation waste generation)

  - Each module would consist of an 18 inch thick reinforced concrete slab floor, 12 inch thick reinforced concrete walls, and a 12 inch thick reinforced concrete roof

  - A 30 foot wide aisle or central corridor is planned in each module. These corridors would remain open during the life of the facility to allow routine monitoring and inspection

  - Waste would be placed into 20 cubic yard cargo containers (5,000 containers, Total capacity 100,000 cubic yards)

— A double liner system and leachate collection and recovery system would be constructed similar to the Concrete Lined Cell (see Figure E-1). This complies with requirements of 6 CCR 1007-3 Part 264 Subpart N.

— The waste cell facility long term footprint would be approximately six acres

— The entire footprint during construction and placement operations would be approximately 12 acres (Cell area + Lay down areas + Operations areas = 12 acres)

— Groundwater monitoring wells (3 each) will be installed both hydraulically up gradient and down gradient and will be operated from start of construction through the end of post closure monitoring

— Any leachate collected would be treated at an existing onsite facility such as the 374 evaporator, the 910 evaporator, or the 891 treatment building. The costs for treatment and storage of the leachate has been incorporated into the cost estimates.

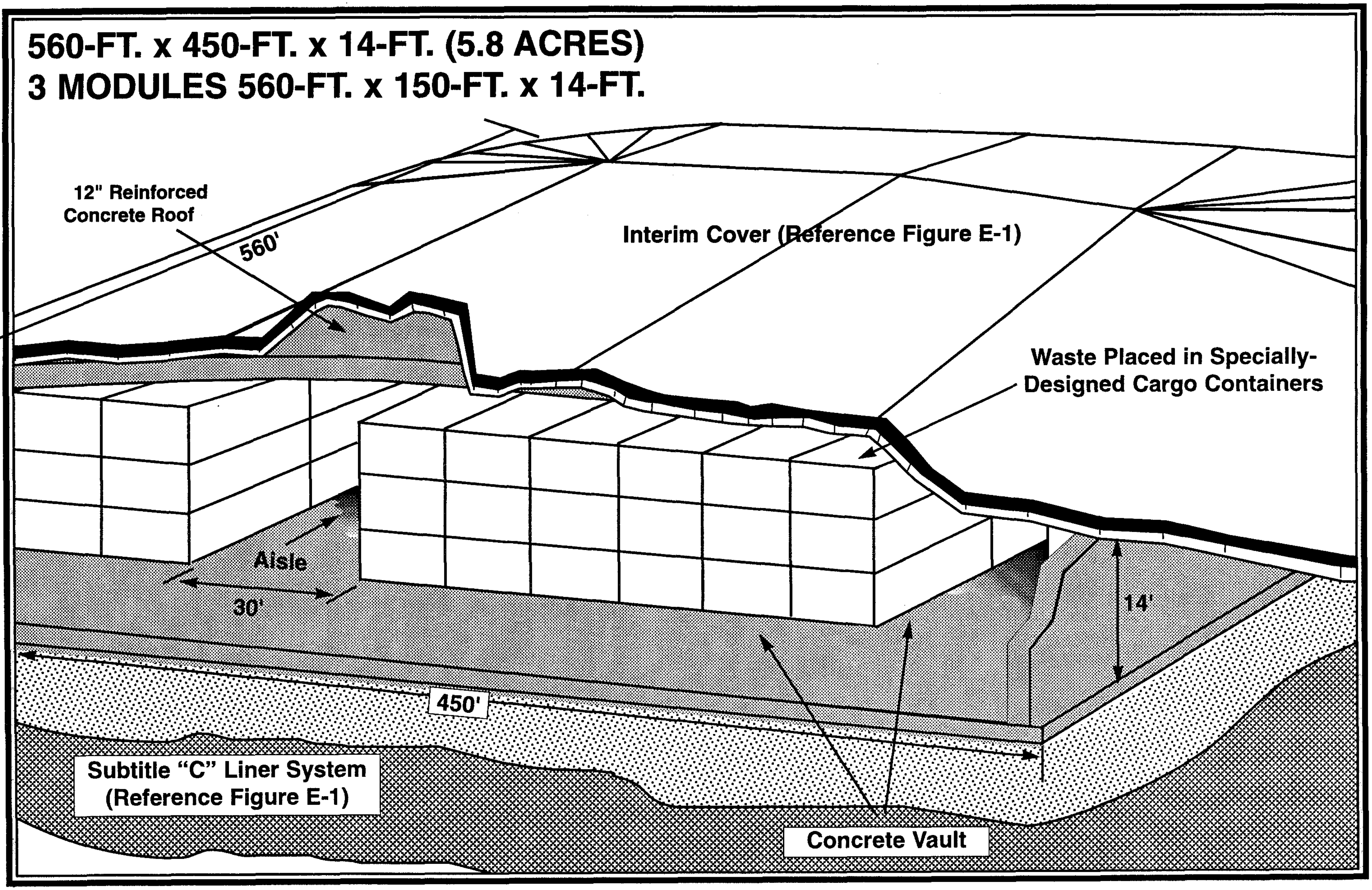

Figure E-4

HARDENED CONCRETE VAULT

TABLE E-4

Hardened Concrete Vault

Task Description	Estimated Cost
Containers	$74,930,000
Packaging	$1,700,000
Characterization	$5,800,000
Transportation	$2,300,000
Design	$2,200,000
Permitting	$300,000
Pre-Construction	$400,000
Site Preparation	$6,100,000
Construction	$26,000,000
Operations	$4,900,000
Cap Installation	$5,300,000
Monitoring	$10,400,000
Final Closure	$3,500,000
Off-Site Disposal	N/A
Contingency	$41,300,000
Total Life Cycle Costs	***$185,130,000***

Note:

Total life cycle costs do not include offsite disposal costs. These costs would include transportation and disposal costs and would add over $15 d

Silo Design

This alternative design consists of a series of 5,000 cubic yard capacity open top concrete silos placed over a double liner and leachate collection system (see Figure E-5). When all of the silos are filled with remediation waste an cover is placed over the entire facility. Remediation waste would be placed in each silo in bulk (without containers) and compacted. When each silo is filled a structural concrete roof is constructed over the silo. Individual waste streams would be mapped and recorded to allow retrieval (by excavation) when desired. Individual silos would be constructed as needed to keep pace with remediation waste generation. This design alternative is based on a similar design described in EG&G- INEL *Interim Report: Waste Management Facilities Costs, Information for Mixed Low-Level Waste,* dated March 1994.

- The following features were used to develop the cost estimate (see Table E-5) and may change during the detailed design. This design complies with requirements of 6 CCR 1007-3 Part 264 Subpart N.

  — This waste cell design includes an cover that complies with 6 CCR 1007-3 Part 264 Subpart N(see Figure E-1). The surface slope of the finished cover would be approximately 4%. Should a long-term cover ever be installed it too would comply with 6 CCR 1007-3 Part 264 Subpart N

  — The side slope of the finished cover would be approximately 12%

  — Leachate collection layer consisting of one foot of coarse sand

  — Primary liner would be composed of an 80 mil geomembrane chemically resistant to the waste and leachate as required by 6 CCR 1007-3 Part 264 Subpart N.

  — The leak detection system includes a geocomposite (e.g., A geonet with a geotextile on each side). All components of the leak detection system must be chemically resistant to the waste and the leachate per the requirements of 6 CCR 1007-3 Part 264 Subpart N.

  — Secondary liner would include three feet of compacted clay, overlain by a 80 mil geomembrane. All components of the secondary liner system must be chemically resistant to the waste and the leachate per the requirements of 6 CCR 1007-3 Part 264 Subpart N.

— Facility size of 500 feet wide by 500 feet long by approximately 75 feet high

— The waste cell facility long term footprint would be approximately six acres

— Self supporting open top reinforced concrete shell silos approximately 50 feet wide by 40 feet long by 70 feet high. Each silo to be constructed with 12 inch thick reinforced concrete walls and an 18 inch thick reinforced concrete slab floor. When filled with waste, a 12 inch thick structural concrete top would be constructed over each silo.

— Space between silos would be backfilled with clean sand or fill

— The entire footprint during construction and placement operations would be approximately 12 acres (Cell area + Lay down areas + Operations areas = 12 acres)

— Groundwater monitoring wells (3 each) will be installed both hydraulically up gradient and down gradient and will be operated from start of construction through the end of post closure monitoring

— Any leachate collected would be treated at an existing on-site facility such as the 374 evaporator, the 910 evaporator, or the 891 treatment building. The costs for treatment and storage of the leachate has been incorporated into the cost estimates.

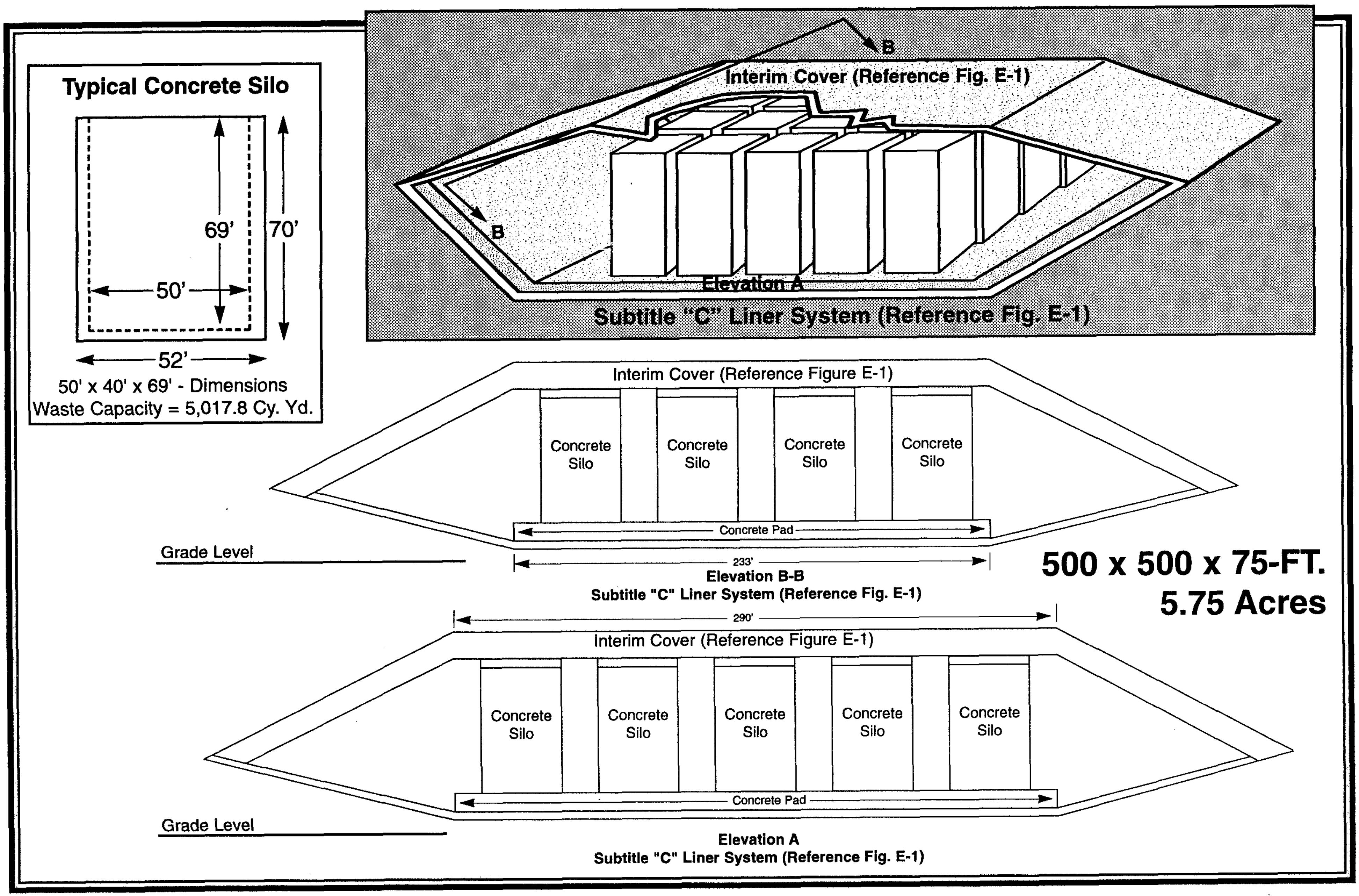

Figure E-5

SILO DESIGN

TABLE E-5

Silo Design

Task Description	Estimated Cost
Containers	$0
Packaging	$2,100,000
Characterization	$5,800,000
Transportation	$2,300,000
Design	$2,000,000
Permitting	$300,000
Pre-Construction	$400,000
Site Preparation	$6,100,000
Construction	$30,400,000
Operations	$14,300,000
Cap Installation	$5,300,000
Monitoring	$13,900,000
Final Closure	$7,000,000
Off-Site Disposal	N/A
Contingency	$24,400,000
Total Life Cycle Costs	*$114,300,000*

Note:
Total life cycle costs do not include offsite disposal costs. These costs would include transportation and disposal costs and would add over $150 million dollars to the total cost.

Slab on Grade

This alternative design consists of 5,000, twenty cubic yard capacity, cargo containers filled with remediation waste placed outdoors on an abovegrade concrete slab (see Figure E-6). No liner or leachate collection system is incorporated into this design. A concrete berm around the perimeter of the slab and a sump to contain stormwater are integrated into the design. No roof or building enclosure would be placed over the cargo containers. The facility would have a design life of 30 years, at which time it was assumed that the waste would be transported to an off site facility for disposal. This concept is currently in use for storage of RCRA waste at RFETS.

- The following features were used to develop the cost estimate (see Table E-6) and could change during detailed design.

  — The waste would be placed in bulk into the 20 cubic yard cargo containers

  — No double liner system of the leachate collection and recovery system

  — Facility design life of 30 years

  — Requires 5,000 each 20 cubic yard cargo containers, whose design life was assumed to be 30 years in outdoor storage

  — The footprint of the facility would be approximately 535 feet by 600 feet

  — The containers would be stacked three high and placed in double rows with a 5 foot aisle between the double rows

  — The slab with a perimeter stormwater curb would be constructed of reinforced concrete at the existing grade

  — The slab would be sloped to a central sump for storm water collection. For estimating purposes it was assumed that the storm water could be discharged without treatment.

  — Any costs associated with maintenance or replacement of the facility at the end of the design life were not included in this estimate

  — The site footprint during long term storage would be approximately 7 acres

— The entire footprint during construction and placement operations would be approximately 12 acres (Cell area + Lay down areas + Operations areas = 12 acres)

— Groundwater monitoring wells (3 each) will be installed both hydraulically up gradient and down gradient and will be operated from start of construction through the life cycle (30 years).

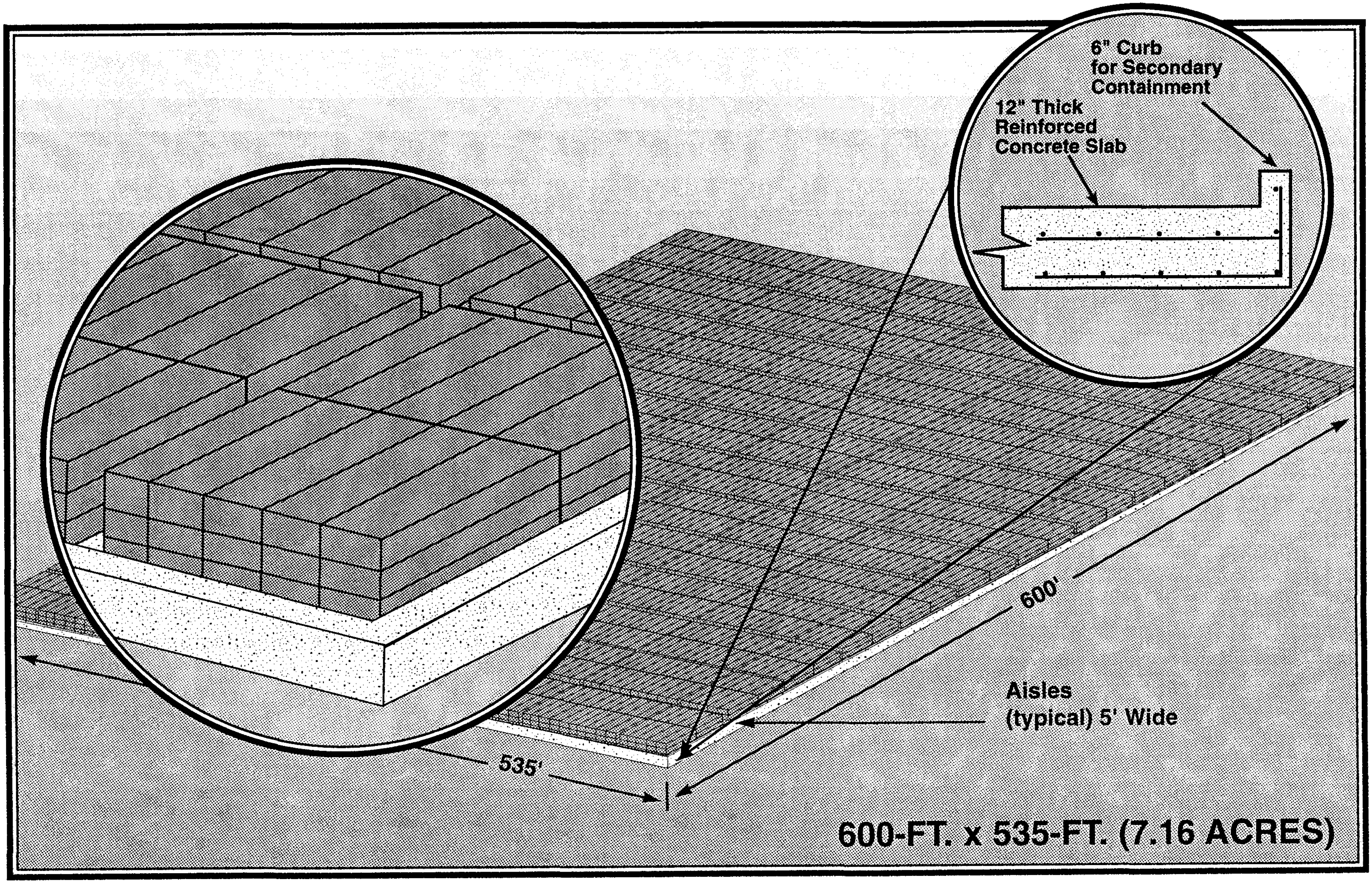

Figure E-6

SLAB ON GRADE

TABLE E-6

Slab on Grade

Task Description	Estimated Cost
Containers	$74,900,000
Packaging	$1,700,000
Characterization	$5,800,000
Transportation	$2,300,000
Design	$300,000
Permitting	$300,000
Pre-Construction	$200,000
Site Preparation	$6,100,000
Construction	$3,800,000
Operations	$5,500,000
Cap Installation	N/A
Monitoring	$8,500,000
Final Closure	$1,800,000
Off-Site Disposal	N/A
Contingency	$32,200,000
Total Life Cycle Costs	*$143,400,000*

Note:
Total life cycle costs do not include offsite disposal costs. These costs would include transportation and disposal costs and would add over $150 million dollars to the total cost.

Metal Buildings

This alternative design consists of 5,000, twenty cubic yard capacity, cargo containers filled with remediation waste placed inside engineered metal buildings (see Figure E-7). This design alternative is very similar to the Slab-on-Grade design with the exception that in this design option, the cargo containers are sheltered from the weather, and that no storm water would be collected. The buildings would be constructed on a concrete slab. No liner or leachate collection system is incorporated into this design. The facility would have a design life of 30 years, at which time it was assumed that the waste would be transported to an off site facility for disposal. This concept is currently in use for storage of RCRA waste at RFETS.

- The following features were used to develop the cost estimate (see Table E-7) and could change during detailed design.

  — Four metal buildings, each 570 feet long by 130 feet wide by 20 feet high

  — One building would be constructed per year

  — Each building would be placed on a 12 inch thick concrete slab

  — 5,000 each 20 cubic yard capacity cargo containers

  — The containers would be stacked three high in the buildings

  — Each building would retain one centralized corridor and access aisle for routine monitoring and inspection for the design life of the facility

  — 30 year design life of the facility

  — Large forklifts to move the cargo containers

  — Transportation of the waste to an off site disposal facility at the end of the design life

  — No double liner system or leachate collection and recovery system

  — Cost of maintaining or replacing this Remediation Waste Storage facility after the design life were not considered in this cost estimate

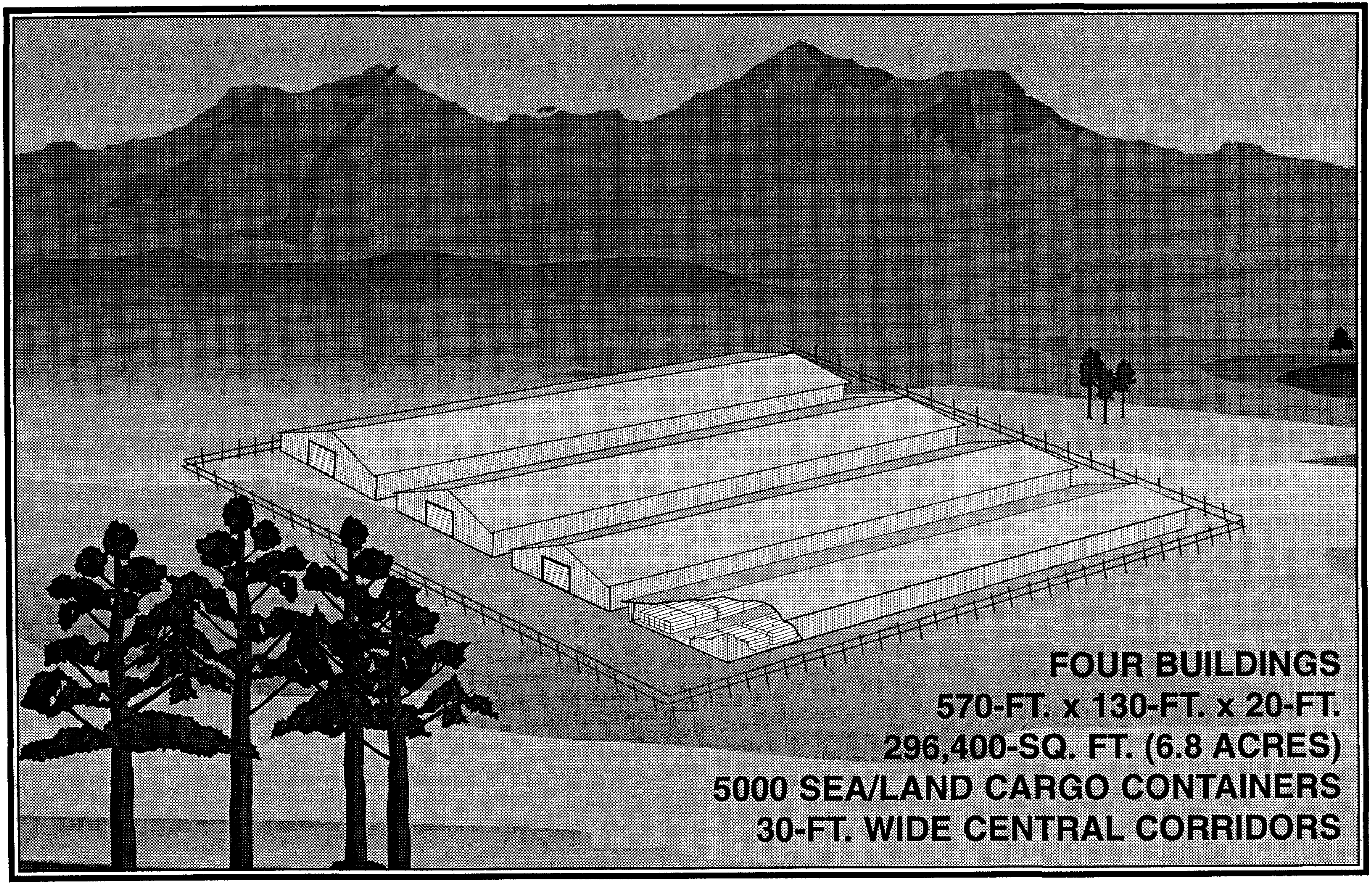

Figure E-7

METAL BUILDINGS

TABLE E-7

Metal Buildings

Task Description	Estimated Cost
Containers	$74,900,000
Packaging	$2,400,000
Characterization	$5,800,000
Transportation	$1,700,000
Design	$2,300,000
Permitting	$300,000
Pre-Construction	$1,300,000
Site Preparation	$2,800,000
Construction	$17,900,000
Operations	$4,900,000
Cap Installation	N/A
Monitoring	$10,400,000
Final Closure	$2,600,000
Off-Site Disposal	N/A
Contingency	$36,700,000
Total Life Cycle Costs	*$164,000,000*

Note:
Total life cycle costs do not include offsite disposal costs. These costs would include transportation and disposal costs and would add over $150 million dollars to the total cost.

Entombment

Essentially, in this alternative design concept, remediation waste is placed into 55 gallon steel drums. Eight steel drums are then placed into a large concrete canister (or concrete box) which is then filled with grout. The canisters are stored in a weatherproof hardened concrete vault. This design option is intended for long term retrievable storage (see Figure E-8). While meeting the definition of Monitorable Retrievable Storage , the actual waste, while highly retrievable would be less monitorable than several of the alternate designs. This design alternative is based on a similar design described in an EG&G-INEL *Interim Report: Waste Management Facilities Cost Information for Low Level Waste*, dated March 1994.

This design combines several concepts of some of the previous design alternatives, it is most similar to the hardened concrete vault design. The most significant difference is that each waste canister is entombed in concrete. The remediation waste is placed into 55 gallon steel drums. Eight drums are placed into a single larger canister (concrete box), which is then sealed by filling it with (cement) grout. The canisters are then placed into the storage facility which consists of a series of adjacent hardened concrete cells (vaults). The facility would be constructed over a double liner and leachate collection system. The facility itself would consist of rows of concrete cells having an access aisle between the rows. The canisters are placed into the open topped concrete cells, and stacked three high. When a cell is filled with canisters the void spaces in the cell (between the canisters and cell walls), are backfilled with sand and then a concrete cover is constructed on the top of the cell thereby closing the cell. When the cells have been covered with concrete, an cover is constructed over the entire facility.

- The following features were used to develop the cost estimate (see Table E-8) and could change during detailed design. This design option complies with 6 CCR 1007-3 Part 264 Subpart N Requirements.

  — This waste cell design includes a cover system that meets the intent of the design requirements for covers in 6 CCR 1007-3 Part 264 Subpart N recognizing the limited operational life of 25 years.(see Figure E-1). The surface slope of the finished cover would be approximately 4%. Should a cover be needed for a longer duration it too would comply with 6 CCR 1007-3 Part 264 Subpart N.

  — A leachate collection layer consisting of one foot of coarse sand

  — The primary liner would be composed of an 80 mil geomembrane chemically resistant to the waste and leachate as required by 6 CCR 1007-3 Part 264 Subpart N.

— The leak detection system includes a geocomposite (e.g., A geonet with a geotextile on each side). All components of the leak detection system must be chemically resistant to the waste and the leachate per the requirements of 6 CCR 1007-3 Part 264 Subpart N.

— Secondary liner would include three feet of compacted clay, overlain by a 80 mil geomembrane. All components of the secondary liner system must be chemically resistant to the waste and the leachate per the requirements of 6 CCR 1007-3 Part 264 Subpart N.

— Each cell floor would be reinforced concrete

— The canisters would be stacked three high in the cells with each canister holding 8 drums

— Each cell would have one adjacent aisle for routine monitoring and inspection

— 1,000 year design life of the facility

— Groundwater monitoring wells (3 each) will be installed both hydraulically up gradient and down gradient and will be operated from start of construction through the end of post closure monitoring

— Any leachate collected would be treated at an existing onsite facility, and those costs were not included in the estimate such as the 374 evaporator, the 910 evaporator, or the 891 treatment building. The costs for treatment and storage of the leachate has been incorporated into the cost estimates.

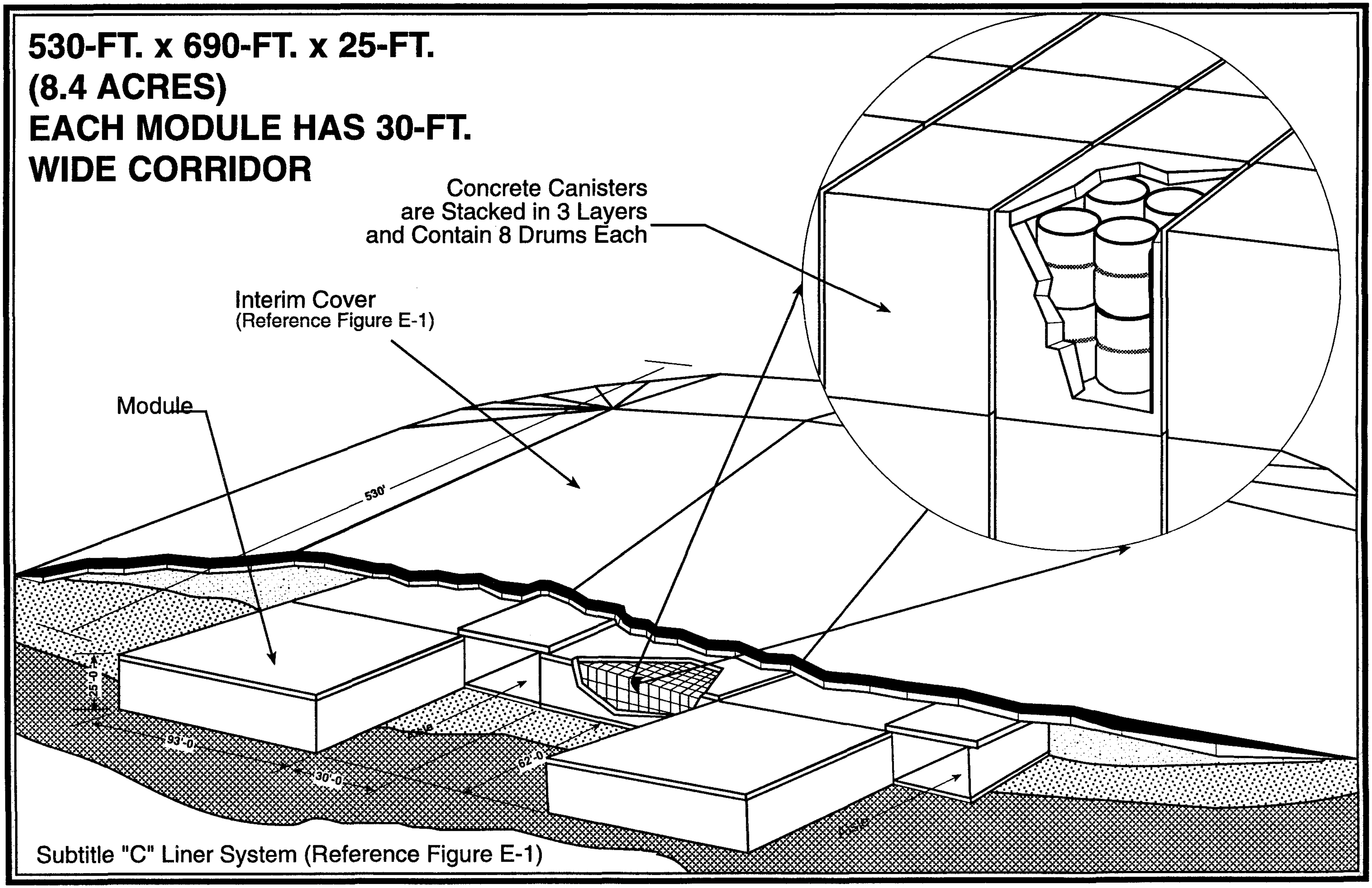

Figure E-8

ENTOMBMENT

TABLE E-8

Entombment

Task Description	Estimated Cost
Total Cost	$525,000,000
Final Closure	$8,800,000
Total Life Cycle Costs	*$533,800,000*

Note: Based on Idaho National Engineering Laboratory report, "Waste Management Facilities Cost Information for Mixed Low Level Waste", dated March 1994.

Total life cycle costs do not include offsite disposal costs. These costs would include transportation and disposal costs and would add over $150 million dollars to the total cost.

Pyramid Design

This alternative design concept is to construct a pyramid around compacted remediation waste in bulk (see Figure E-9). The base/floor of the pyramid would have a rectangular footprint and constructed to be a structurally sound base of slab-on-grade reinforced concrete and quarried stone. The structure/facility would be built in a series of compacted lifts of remediation waste with a "ring" of quarried stone blocks forming the perimeter. The length of the perimeter would decrease as the height increased. It is believed that the quarried stone blocks would not exclude all stormwater over time. Sealant would be used between the quarried stone blocks to prevent stormwater from infiltrating the compacted waste. This design alternative was described and estimated as a result of input from the Citizens Advisory Board.

It was perceived that the ease of monitoring a selected remediation waste would be among the lowest of the options considered. In addition, the structural integrity of the facility would be provided by the compacted waste itself. The quarried stone blocks, due to their large size, would be extremely expensive to procure, transport, and install. Due to the limited mass of stone relative to the mass of compacted waste, the quarried stone blocks themselves would contribute little to the overall integrity of the facility. A sealant placed between the blocks would be expected to fail when differential settling of the waste occurred, allowing stormwater to enter the waste. Because the engineering properties of the remediation waste (if any) have yet to be defined, it is not clear if the compacted waste would support the quarried stone blocks. Imposing strict physical structural requirements upon the waste to be placed into the pyramid in order to achieve the necessary structural integrity for the intended purpose could exclude significant quantities of remediation waste from this facility or that the waste be treated to a defined strength requirement at additional cost.

For these reasons the pyramid design was discarded after initial cost estimates (see Table E-9) were prepared.

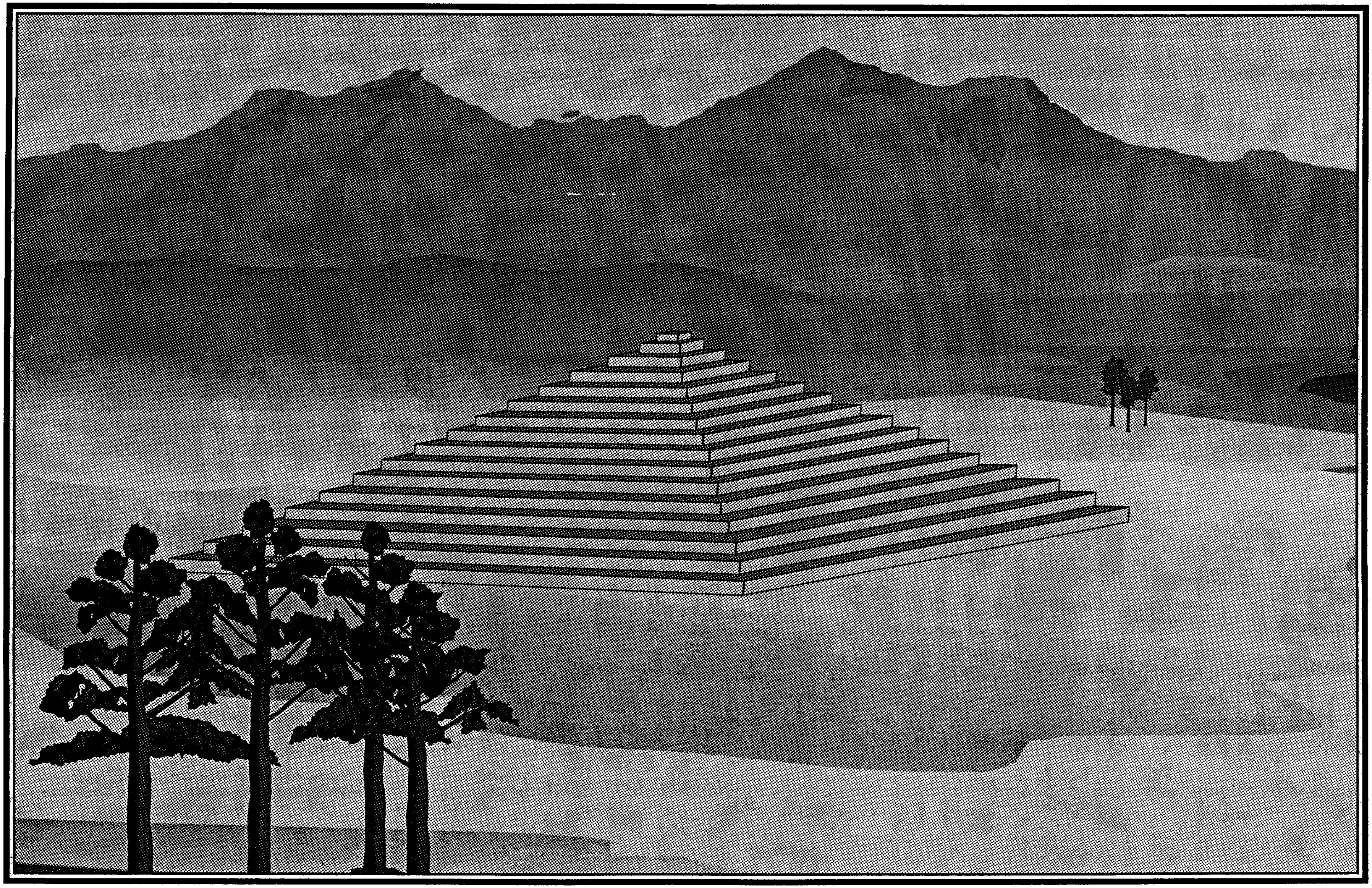

Figure E-9
PYRAMID

TABLE E-9

Pyramid Design

Task Description	Estimated Cost
Containers	$0
Packaging	$2,100,000
Characterization	$5,800,000
Transportation	$2,300,000
Design	$2,200,000
Permitting	$300,000
Pre-Construction	$400,000
Site Preparation	$14,500,000
Construction	$57,900,000
Operations	$9,000,000
Cap Installation	N/A
Monitoring	$13,900,000
Final Closure	$1,500,000
Off-Site Disposal	N/A
Contingency	$31,900,000
Total Life Cycle Costs	*$141,800,000*

Note:
Total life cycle costs do not include offsite disposal costs. These costs would include transportation and disposal costs and would add over $150 million dollars to the total cost.

Waste Pile

This alternative design concept was patterned after the Waste Pile constructed in 1988 at the Rocky Mountain Arsenal. The design was developed and implemented to isolate Basin F hazardous soils and sludges from the environment pending selection of a treatment method and a disposal site. In this concept wastes-in-bulk are compacted into a rectangular pile, covered with a geomembrane , (bottom, sides, and top) and dirt which is vegetated with native grasses (see Figure E-10). No special embankments, pits, buildings, or berms are employed. As the pile is constructed of compacted waste, the waste is covered (daily) with a plastic membrane to prevent the spread of contamination. When complete the pile is sealed within a geomembrane. The geomembrane would be covered with fill dirt and vegetated with native grasses. This alternative would provide 30 year monitored retrievable storage of remediation waste pending agreement by the public, the regulators, and the DOE as to disposition. See Table E-10 for a conceptual cost estimate.

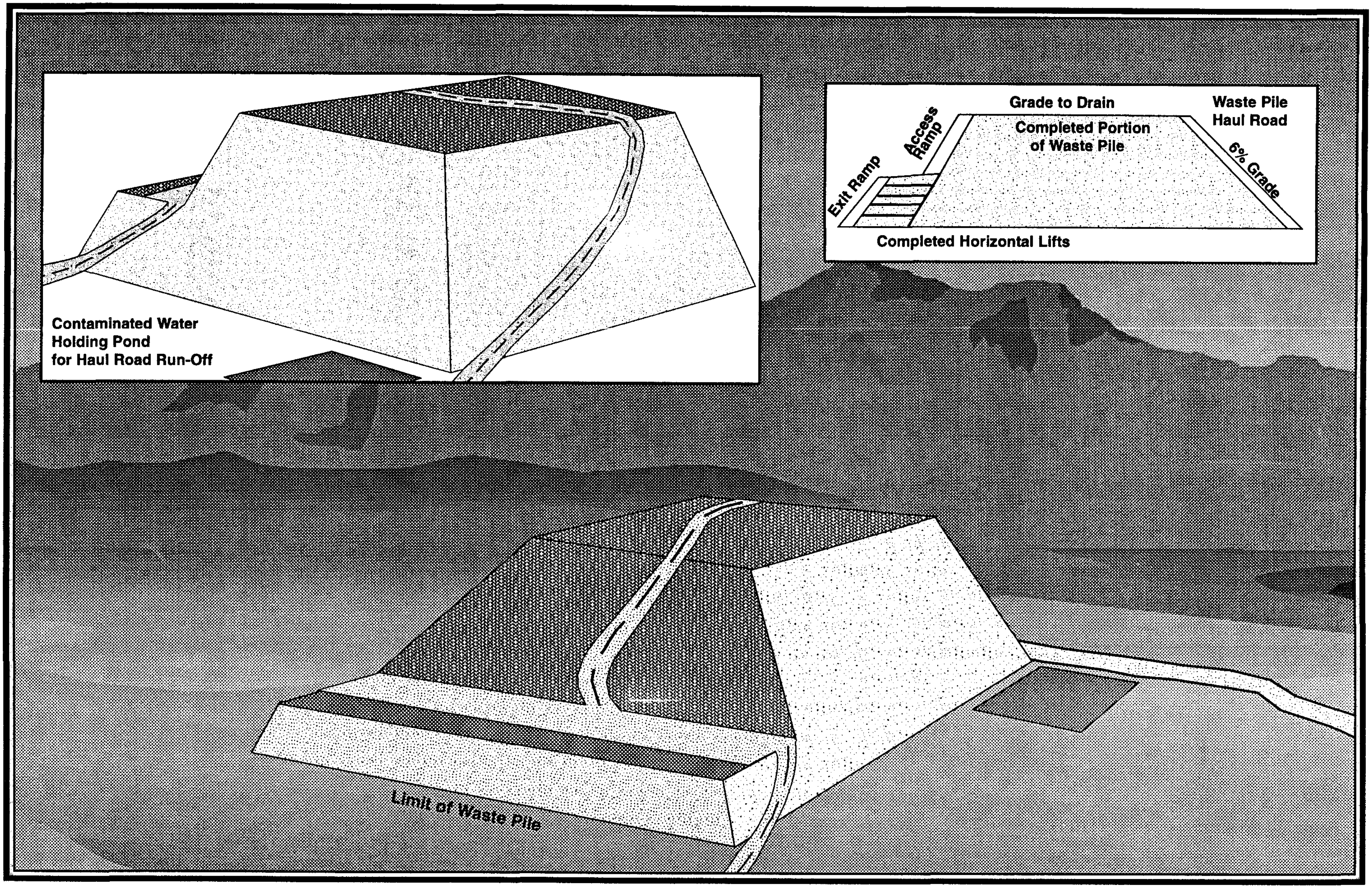

Figure E-10
WASTE PILE

TABLE E-10

Waste Pile

Task Description	Estimated Cost
Actual Costs (Escalated 1988 to 1996)	$36,669,000
Final Closure	$300,000
Off-Site Disposal	N/A
Total Life Cycle Costs	*$36,969,000*

Note:
Total life cycle costs do not include offsite disposal costs. These costs would include transportation and disposal costs and would add over $150 million dollars to the total cost.

No Action

The "No Action" alternative is included in this listing of design options to fulfill the requirements of both NEPA and CERCLA regulations. Both require that the "No Action" option continues to be considered through the end of the decision making process.

The Proposed Action is an onsite facility

The proposed action is to permit and construct an onsite storage facility to contain remediation waste(s) generated as part of the cleanup and closure activities at RFETS. This facility would be designed and permitted as a CAMU, a storage facility to isolate the wastes from the environment in a retrievable fashion. This facility would be designed to meet RCRA Subtitle "C" Landfill facility requirements. Permitted storage under a CAMU permit would allow the waste to remain non-Land Disposal Requirements (LDR) compliant for the period of storage. This storage would allow an indefinite period of time for the general public, the DOE and the CDPHE to determine and agree upon the ultimate fate (disposal) of the wastes via a Record of Decision (ROD).

The No Action Alternative is to ship remediation waste off site as soon as it is produced

The No Action option is to package and ship all remediation waste generated as part of the cleanup and closure activities to an off site disposal facility, as a permitted onsite hazardous, LLW, or LLMW disposal facility does not exist. This means that the schedules for risk reduction activities would be based upon the ability to ship remediation waste as it is generated. In the event remediation waste cannot be shipped, risk reduction activities would be delayed. See Table E-11 for the conceptual cost estimate summary.

TABLE E-11

No Action

(Offsite disposal concurrent with generation)

Task Description	Estimated Cost
Containers	$0
Packaging	$0
Treatment/Characterization	$0
Transportation	$0
Design	N/A
Permitting	N/A
Pre-Construction	N/A
Site Preparation	N/A
Construction	N/A
Operations	N/A
Cap Installation	N/A
Monitoring	N/A
Final Closure	N/A
Off-Site Disposal (years 1997,8,9)	$0
Contingency *	$0
Total Life Cycle Costs	*$0*

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Appendix F - Backup for Facility Design Screen

This appendix provides details of the facility design screen for each of the major criteria. This appendix backs up information provided in Table 6-1. Specific criteria have been referenced in parentheses (e.g., [Criterion #.#]). Additional information on specific criteria can be found in Section 5 and Appendix D.

F.1 ABOVEGRADE STORAGE CELL

Description:

This facility is similar in construction to a typical waste management cell except that fill would be used to build up the sides of the cell so it could be placed abovegrade. A more detailed description of this design is given in Appendix E.

CAMU Criteria:

Many of the features of the abovegrade storage cell support a CAMU designation. The facility would have a double liner, a leachate collection system, and an impermeable cap to ensure that releases do not occur (Criterion 1.4). The facility could well support the timing of remedial activities since it is a simple and proficient design and remediation waste can be placed in the facility without as much additional processing (Criterion 1.5). Because waste could be placed in bulk, remediation waste could go from treatment or excavation directly into the cell. Construction and of the facility could be expedient because the design is simple and the technology is readily available and well known.

Public Protection (Geotechnical and Hydrological Criteria)

The abovegrade storage cell has many of the advantages of other designs including double liners and a shallow slope around the edge of the structure to protect against erosion (Criteria 2.1 & 2.3). The double liner system and abovegrade design would isolate the facility from the substrate and ground water (Criteria 2.3, 2.10, & 2.12). The impermeable cap could have an impact on surface water drainage and groundwater infiltration since water will be diverted to the edges of the cap (Criterion 2.11).

Site Special Issues:

The abovegrade storage cell would require a larger footprint than many other designs because of the additional space required to construct the embankment around the facility. To ensure slope stability, the embankment would be at a five to one slope. This would impact the ability to collocate other waste facilities next to this facility (Criterion 3.9) and could impact some additional utilities (Criterion 3.2). Other than space considerations, it would support the Site Vision well because the storage cell cap could be tied into the cap planned for the Industrial Area of the Site (Criterion 3.1).

Cost Criteria:

The Cost of Construction (Criterion 4.1) was calculated as follows:

Design	$2,200,000
Pre-Construction	$400,000
Construction	$41,700,000
Total Cost of Construction	$44,300,000

The Cost of Site Preparation (Criterion 4.2) is:

Cost of Site Preparation	$8,800,000

The Cost of Closure (Criterion 4.3) was calculated as follows:

Cover	$5,300,000
Monitoring	$13,900,000
Final Closure	$400,000
Total Cost of Closure	$19,600,000

The above costs were combined with the costs for containers, packaging, characterization, transportation, permitting, operations, and contingency to yield the Total Life-Cycle Cost (Criterion 4.4):

Total Life-Cycle Cost	$119,200,000

The cost of construction would be high because of the cost of fill material that would be used to build up the embankments and because of all of the earthwork that would be required to place that fill (Criterion 4.1). The low total life cycle cost (Criterion 4.4) would be the result of onsite management in bulk form and potentially low closure costs (Criterion 4.3). As with the other onsite alternatives, life cycle cost does not include the eventual cost of offsite disposal which would include retrieval, packaging, transportation and disposal costs. The inclusion of these costs would increase the total life-cycle cost significantly (by more than $150 million).

Regulatory Support:

In terms of the regulatory support criteria, this facility would not have a lot of future applicability or utility outside of its use to manage bulk waste (Criterion 5.4). For any use, only low level waste would be put in this type of facility (Criterion 5.5). Also, this design is more the current standard than it is state of the art (Criterion 5.3) although the liner and the cap have the potential to be a state of the art design.

Other Stakeholder Concerns:

This would be one of the simpler facilities to design and construct (Criterion 6.10). The needed materials, services and technologies would be readily available (Criteria 6.12 & 6.13). In terms of schedule requirements, this facility could be both expediently constructed and expediently operated (Criterion 6.11) because:

- The design is simple
- The materials are easy to obtain
- The waste can be placed directly into the facility in bulk
- The technology is well known

F.2 CONCRETE LINED CELL WITH BULK PLACEMENT

Description:

Bulk waste would be placed in modular concrete cells. A double liner and a leachate collection system would be under the facility. Upon filling the cells an impermeable cap would placed above them if offsite shipment is not readily available. A more detailed description of this design is given in Appendix E.

CAMU Criteria:

The concrete walls and floors provide an additional barrier of protection to prevent leakage (Criterion 1.4). This design supports the timing of remedial activities in a number of ways (Criterion 1.5). Waste would be placed in bulk, so remediation waste could go from treatment or excavation directly into the cell. Construction of the facility would be expedient because the design is simple and the technology is readily available and well known. The modular design allows use after filling of the cells while other are under construction so the facility could start accepting waste prior to the completion of construction and support active offsite shipment.

Public Protection (Geotechnical and Hydrological Criteria):

The combination of abovegrade design and a double liner barrier will provide reasonable assurances that groundwater and subsurface soils are protected (Criteria 2.1, 2.5 & 2.10). Structurally, the concrete walls could provide additional structural stability (Criterion 2.3). Drainage and infiltration could be impacted by the impermeable cover (Criterion 2.11). Geomorphic effects will be minimized by maintaining a gentle slope and by forcing the design to accommodate surface features and the existing drainage patterns (Criteria 2.2 & 2.11).

Site Special Issues:

This option has a smaller footprint than some designs although it is slightly larger than the hardened concrete vault. This design well supports Site Vision objectives (Criterion 3.1) since the facility could be part of a continuous cap planned for the Industrial Area and the smaller size of the facility means less total space for managing waste. The modular design should facilitate the placement of similar structures near this facility since walls of the unit could be shared with new modules allowing additional units to be placed right beside existing ones (Criterion 3.9). The use of modules in this design will also enhance the ability of the facility to accept a variety of remediation waste types including Decontamination and Decommissioning waste (Criterion 3.6).

Cost Criteria:

The Cost of Construction (Criterion 4.1) was calculated as follows:

Design	$1,600,000
Pre-Construction	$150,000
Construction	$18,600,000
Total Cost of Construction	$20,350,000

The Cost of Site Preparation (Criterion 4.2) is:

Cost of Site Preparation	$1,970,000

The Cost of Closure (Criterion 4.3) was calculated as follows:

Cover	$5,300,000
Monitoring	$13,000,000
Final Closure	$1,800,000
Total Cost of Closure	$20,100,000

The above costs are combined with the costs for containers, packaging, characterization, transportation, permitting, operations, and contingency to yield the Total Life-Cycle Cost (Criterion 4.4):

Total Life-Cycle Cost	$79,120,000

Low construction, site preparation, and closure costs (Criteria 4.1, 4.2, & 4.3) plus cost savings resulting from bulk storage of the waste would give the lowest total life cycle costs (Criterion 4.4). As with the other onsite alternatives, life cycle cost does not include the eventual cost of offsite disposal which would include retrieval, packaging, transportation and disposal costs. The inclusion of these costs would increase the total life-cycle cost significantly (by more than $150 million).

Regulatory Support:

This facility design would offer a greater degree of applicability and utility than many of the other designs and is permitable (Criteria 5.3 & 5.4). It is a state of the art design (Criterion 5.3) used in Europe for similar applications. Only waste with a radionuclide activity of less than100 nCi/g is currently planned for this type of facility (Criterion 5.5).

Other Stakeholder Concerns:

The modular concrete lined cell allows for a variety of materials to be placed into the facility while still maintaining the ability to retrieve the waste (Criterion 6.6). This facility would offer long-term effectiveness since it has additional barriers between the waste and the environment (Criteria 6.7 &

6.9). The demonstrated performance is better known since this design adds the additional protection of concrete to a storage cell type cap and liner system (Criterion 6.9). Because of the concrete work, this design is expect to be more work intensive in terms of construction but less intensive in terms of operation since it will be a bulk facility (Criterion 6.10). Because the waste could be placed in bulk, it could go directly into the facility after treatment or excavation. Materials, services, and the technology would be readily available (Criteria 6.12 & 6.13).

F.3 CONCRETE LINED CELL IN CARGO CONTAINERS

Description:

Waste would be put into cargo containers and then placed in modular concrete cells. A double liner and a leachate collection system would be under the facility. Upon filling the cells an impermeable cap would placed above them if offsite disposal is not readily available. A more detailed description of this design is given in Appendix E.

CAMU Criteria:

The concrete walls and floors provide an additional barrier of protection to prevent leakage (Criterion 1.4). Construction and of the facility could be expedient because the design is simple and the technology is readily available and well known (Criterion 1.5). The modular design allows use after filling of the cells while other are under construction so the facility could start accepting waste prior to the completion of construction and support active offsite shipment.

Public Protection (Geotechnical and Hydrological Criteria):

The cargo containers themselves could provide some structural support ad well as providing an additional barrier to prevent leaking (Criterion 2.3). Further protection of groundwater and the subsurface strata is provided by the concrete base (Criteria 2.5, 2.11 & 2.12). Drainage and erosion could be controlled by maintaining a shallow slope and by adjusting the design to account for existing drainage; however the impermeable cover would still have some impact (Criterion 2.10).

Site Special Issues:

This option has a smaller footprint than some designs although it is slightly larger than the hardened concrete vault. This design well supports Site Vision objectives (Criterion 3.1) since the facility could be part of a continuous cap planned for the Industrial Area and the smaller size of the facility would mean less total space for managing waste. The modular design would facilitate the placement of similar structures near the facility since walls of the unit could be shared with new modules allowing additional units to be placed right beside existing ones (Criterion 3.9). The use of modules in this design will also enhance the ability of the facility to accept a variety of remediation waste types including Decontamination and Decommissioning waste (Criterion 3.6).

Cost Criteria:

The Cost of Construction (Criterion 4.1) is calculated as follows:

Design	$1,600,000
Pre-Construction	$150,000
Construction	$18,600,000
Total Cost of Construction	$20,350,000

The Cost of Site Preparation (Criterion 4.2) is:

Cost of Site Preparation	$1,970,000

The Cost of Closure (Criterion 4.3) is calculated as follows:

Cover	$5,300,000
Monitoring	$10,400,000
Final Closure	$1,800,000
Total Cost of Closure	$17,500,000

The above costs are combined with the costs for containers, packaging, characterization, transportation, permitting, operations, and contingency to yield the Total Life-Cycle Cost (Criterion 4.4):

Total Life-Cycle Cost	$167,450,000

Low construction costs (Criterion 4.1) would offset the cost for containers to yield a relative low total life-cycle cost (Criterion 4.4). As with the other onsite alternatives, life cycle cost does not include the eventual cost of offsite disposal which would include retrieval, packaging, transportation and disposal costs. The inclusion of these costs would increase the total life-cycle cost significantly (by more than $150 million).

Regulatory Support:

This facility design would offer a greater degree of applicability and utility than many of the other designs and is permitable (Criteria 5.3 & 5.4). It is a state of the art design (Criterion 5.3) used in Europe for similar applications. Only low-level remediation waste is currently planned for this type of facility design (Criterion 5.5).

Other Stakeholder Concerns:

The use of containers better supports retrievability since the waste will be segregated, accessible and easier to inspect and remove (Criteria 6.1 & 6.2). As with the concrete lined call with bulk management, it compares favorably to the other designs in terms of useful life, effectiveness, demonstrated performance, and the availability of the technology, services and materials (Criteria 6.7, 6.9, 6.12, & 6.13). It will take additional time to construct than some of the other abovegrade designs due to all of the concrete work (Criteria 6.10 & 6.11). Operations will be slightly more intensive than the concrete lined bulk facility due to the use of containers (Criteria 6.10 & 6.11).

F.4 HARDENED CONCRETE VAULT

Description:

Remediation waste inside cargo containers would be stored in a modular, abovegrade, self-supporting concrete structure placed over a double liner and leachate collection system. A more detailed description of this design is given in Appendix E.

CAMU Criteria:

This design has additional features that enhance its protectiveness including additional barriers provided by concrete walls and floors and the containers (Criterion 1.1). The waste would be very accessible since aisle ways would be present and containers could be removed and visually inspected for leaks. The modular design would allow use of one module prior to completion of the facility. This would allow use of the facility to be available sooner (Criterion 1.5).

Public Protection (Geotechnical and Hydrological Criteria):

Concrete walls and floor could provide some additional structural support and an additional protective barrier. Impermeable cap could impact drainage and infiltration patterns (Criterion 2.11).

Site Special Issues:

The footprint for the hardened concrete vault would not be as large as many of the other designs considered. It would be easier to place additional facilities next to this facility because of its smaller foot print and concrete walls (Criterion 3.9). One drawback would be that it could take a little longer to design and build and the filling of the facility is more work intensive and would take resources always from other Site closure activities (Criterion 3.1). It would take longer to fill each vault which could also cause scheduling problems.

Cost Criteria:

The Cost of Construction (Criterion 4.1) was calculated as follows:

Design	$2,200,000
Pre-Construction	$400,000
Construction	$26,000,000
Total Cost of Construction	$28,600,000

The Cost of Site Preparation (Criterion 4.2) is:

Cost of Site Preparation	$6,100,000

The Cost of Closure (Criterion 4.3) was calculated as follows:

Cover	$5,300,000
Monitoring	$10,400,000
Final Closure	$3,500,000
Total Cost of Closure	$19,200,000

The above costs are combined with the costs for containers, packaging, characterization, transportation, permitting, operations, and contingency to yield the Total Life-Cycle Cost (Criterion 4.4):

Total Life-Cycle Cost	$185,130,000

In spite of high site preparation costs (Criterion 4.2), moderately high closure costs (Criterion 4.3) and the cost for containers, the life-cycle cost would compare favorable with the other designs considered (Criterion 4.4). As with the other onsite alternatives, life cycle cost does not include the eventual cost of offsite disposal which would include retrieval, packaging, transportation and disposal costs. The inclusion of these costs would increase the total life-cycle cost significantly (by more than $150 million).

Regulatory Support:

This design could have utilized for other applications including management of other waste types because there would be access aisles and it would be designed to hold cargo containers which could be used for other materials as well (Criterion 5.4). It is a state of the art design (C 5.3).

Other Stakeholder Concerns:

This facility offers a high degree of monitorability and retrievability (Criteria 6.1 & 6.2) because there would be aisles for access, the waste would be in containers, and the modular design would enhance the ability to segregate and track the waste. In terms of construction and operation, this design would be more intensive (Criterion 6.10) since additional effort would be required to construct the concrete vaults walls. During operations additional effort would be needed in containerizing the waste. The materials, services, or the technology needed to construct and operate this facility would be readily available (Criteria 6.12 & 6.13).

F.5 SILO DESIGN

Description:

Concrete silos would be placed over a double composite liner system and leachate collection system. Remediation waste would be placed in the silos in bulk Upon completion of filling operations, the entire facility would be covered with a cap if offsite disposal is not readily available. A more detailed description of this design is given in Appendix E.

CAMU Criteria:

The concrete silos, double liner and leachate collection system enhance the protectiveness of this design (Criterion 1.1). Bulk placement in the silos would be easy to place but inspection would be limited.

Public Protection (Geotechnical and Hydrological Criteria):

The cap could impact drainage and infiltration patterns (Criterion 2.11)

Site Special Issues:

The cap and small footprint would tie in well into the planned cap for the Industrial Area Cap as part of the Site Vision (Criterion 3.1).

Cost Criteria:

The Cost of Construction (Criterion 4.1) is calculated as follows:

Design	$2,000,000
Pre-Construction	$400,000
Construction	$30,400,000
Total Cost of Construction	$32,800,000

The Cost of Site Preparation (Criterion 4.2) is:

Cost of Site Preparation	$6,100,000

The Cost of Closure (Criterion 4.3) is calculated as follows:

Cover	$5,300,000
Monitoring	$13,900,000
Final Closure	$7,000,000
Total Cost of Closure	$16,200,000

The above costs are combined with the costs for containers, packaging, characterization, transportation, permitting, operations, and contingency to yield the Total Life-Cycle Cost (Criterion 4.4):

Total Life-Cycle Cost	$114,300,000

Middle of the range construction costs (Criterion 4.1) and low closure costs (Criterion 4.3) combined cost savings from with bulk storage yielded a low life-cycle cost of the facility design alternatives (Criterion 4.4). As with the other onsite alternatives, life cycle cost does not include the eventual cost of offsite disposal which would include retrieval, packaging, transportation and disposal costs. The inclusion of these costs would increase the total life-cycle cost significantly (by more than $150 million).

Regulatory Support:

This design meets some of the state principles. It is a state of the art design (Criterion 5.3) and it is design to be permitted under RCRA (Criteria 5.4 ~~& 5.5~~).

Other Stakeholder Concerns:

This design is not in wide use and so the performance and useful life is not as established (Criteria 6.7, 6.9 & 6.12). The intensive nature of this design would be very demanding in terms of design and construction and would probably take longer to get into operation (F10, F11). The main activities that would affect the schedule would be the additional time setting up forms and filling the silos and additional time preparing the detailed design (Criterion 6.11).

F.6 SLAB ON GRADE

Description:

Waste would be put in cargo containers and placed on an abovegrade slab. A more detailed description of this design is given in Appendix E.

CAMU Criteria:

The Slab on Grade would be quick and easy to install due to its simple design, known technology, and the materials would be easily available. Since the time to complete the design work would be less also due to simplicity and the construction would mostly consist of site preparation and pouring the slab, it is anticipated that this design could be implemented in a relatively short period of time (Criterion 1.5). The use of containers would allow for visual inspection in order to detect leaks prior to contaminants escaping to the environment (Criteria 1.1 & 1.2). Waste containers would be exposed to the elements unless a covering such as tent was placed over the slab. Contaminants that did escape from the containers could be collected in the concrete berm. Any waste material not captured by the concrete berm could escape into the environment.

Public Protection (Geotechnical and Hydrological Criteria):

The ability to meet CAMU criteria is dependent on maintenance of the slab (Criteria 2.5 & 2.10). A slab on grade design would be a temporary facility and the remediation waste would have to be shipped at a later date to some other facility to provide reasonable assurance that it could protect the public for a thousand years (Criterion 2.1). A slab on grade could be engineered to provide adequate drainage (Criterion 2.11), and a permeability of less than 10^{-7} centimeter/second (Criterion 2.5). Slab design would also have to account for settling, expansion and contraction to avoid cracks and structural damage.

Site Special Issues:

The Slab on Grade would have minimal impact on utilities since there is little excavation involved and some overhead utilities could still run over the facility (Criterion 3.2). As with Metal Buildings, this facility could readily support short-term Site Vision goals since it could be designed and constructed in less time, but it is temporary and could remain as an unclosed facility long after other plant facilities have been shut down (Criterion 3.1). The collocation of other waste facilities is a problem only because the slab will have such a large footprint that it could limit the space available for other facilities (Criterion 3.9).

Cost Criteria:

The Cost of Construction (Criterion 4.1) is calculated as follows:

Design	$300,000
Pre-Construction	$200,000
Construction	$3,800,000
Total Cost of Construction	$4,300,000

The Cost of Site Preparation (Criterion 4.2) is:

Cost of Site Preparation	$6,100,000

The Cost of Closure (Criterion 4.3) is calculated as follows:

Cover	N/A
Monitoring	$8,500,000
Final Closure	$1,800,000
Total Cost of Closure	$10,300,000

The above costs are combined with the costs for containers, packaging, characterization, transportation, permitting, operations, and contingency to yield the Total Life-Cycle Cost (Criterion 4.4):

Total Life-Cycle Cost	$143,400,000

Site preparation costs (Criterion 4.2) and construction costs (Criterion 4.1) would be very low because little earth work would be involved and construction would consist mainly of pouring the pad. However, these costs would be insignificant in comparison to the costs for offsite disposal and container costs which would give a very high total life-cycle cost (Criterion 4.4). As with the other onsite alternatives, life cycle cost does not include the eventual cost of offsite disposal which would include retrieval, packaging, transportation and disposal costs. The inclusion of these costs would increase the total life-cycle cost significantly (by more than $150 million).

Regulatory Support:

Like the Metal Buildings design, this RWSF would be designed meet RCRA requirements for permitted storage including the ability to visually inspect the waste (Criterion5.3). The lack of cover and continual exposure of the waste containers to the elements could be an issue in permitting this facility (Criteria 5.3 & 5.4). It would have a good degree of future applicability and utility since it is basically just a concrete pad (Criterion 5.4). Future applications could include other storage uses, a lay down yard, a staging pad for other cleanup operations, or a tent could be constructed over it. This facility design is far from being state of the art (Criterion 5.3) since it really offers nothing new or innovative in the way of waste management.

Other Stakeholder Concerns:

The containers would be exposed to the elements and there would a slight possibility that the run off could get into surface water systems (Criteria 6.2 & 6.7). Due to the simplicity of this design it should be easy to design and construct in less time than the other designs (Criteria 6.10, 6.11, 6.12, & 6.13). Monitoring and retrieval would be well supported by this facility since all sides of the facility are potentially accessible and the containers can be easily moved and inspected. It would have a very short useful life relative to the other designs (Criteria 6.7 & 6.9). The materials, services and technology for this facility would easy to obtain because it a well known technology utilizing common construction materials (Criteria 6.12 & 6.13).

F.7 METAL BUILDINGS

Description:

Waste would be put in cargo containers and placed in four engineered metal buildings constructed on a concrete slab. A more detailed description of this design is given in Appendix E.

CAMU Criteria:

The use of cargo containers would allow visual leak detection; however, the cost for these containers is high (Criterion 1.1). Like the slab on grade, contaminants that did escape from the containers could be collected in the concrete berm. The building roof would protect containers from precipitation and further minimize any possibility of leaching (Criterion 1.1). The simple, proven design and less intensive construction would allow this facility to be available sooner if needed (Criterion 1.1).

Public Protection (Geotechnical and Hydrological Criteria):

The design life of this facility would be less than other alternatives considered (Criterion 2.1). An advantage would be that most leaks could be contained prior to escaping to the environment. The metal building design would be engineered to provide adequate drainage (Criterion 2.11).

Site Special Issues:

The Metal Building design would have a large footprint compared to the other designs because additional space would be needed for aisle ways and to provide spacing between the buildings (Criterion 3.1). The facility could be used before completely constructed since only one building would need to be ready for remediation waste to be placed inside. This would better support the Site Vision objectives of accelerated site clean up; however, its large footprint would not incorporate the Site Vision objective of reducing the foot print of contaminated area (Criterion 3.1). One advantage to the Metal Buildings design is that there would be a little more flexibility in configuring the buildings so that utilities and other features could be worked around (Criterion 3.2). The collocation of other waste facilities would be a problem only because the Metal Buildings would have such a large footprint that it could limit the space available for other facilities (Criterion 3.9).

Cost Criteria:

The Cost of Construction (Criterion 4.1) is calculated as follows:

Design	$2,300,000
Pre-Construction	$1,300,000
Construction	$17,900,000
Total Cost of Construction	$21,500,000

The Cost of Site Preparation (Criterion 4.2) is:

Cost of Site Preparation	$2,800,000

The Cost of Closure (Criterion 4.3) is calculated as follows:

Cover	N/A
Monitoring	$10,400,000
Final Closure	$2,600,000
Total Cost of Closure	$13,000,000

The above costs are combined with the costs for containers, packaging, characterization, transportation, permitting, operations, and contingency to yield the Total Life-Cycle Cost (Criterion 4.4):

Total Life-Cycle Cost	$164,000,000

Low construction costs (Criterion 4.1) would be offset by the cost of containers to yield one of the higher total life-cycle costs (Criterion 4.4). As with the other onsite alternatives, life cycle cost does not include the eventual cost of offsite disposal which would include retrieval, packaging, transportation and disposal costs. The inclusion of these costs would increase the total life-cycle cost significantly (by more than $150 million). Since the waste is in containers, packaging costs would be lower once offsite shipment commenced.

Regulatory Support:

This facility design would be designed meet RCRA requirements for permitted storage including the ability to visual inspect the waste (Criterion 5.3). It would have a good degree of future applicability and utility since it would be basically just a concrete pad (Criterion 5.4). Future applications could include other storage uses or as a building for other closure activities. Like the Slab on Grade, this facility design is not state of the art (Criterion 5.3) since it really offers nothing new or innovative in the way of waste management.

Other Stakeholder Concerns:

Monitoring and retrieval could be performed from the aisle ways in each buildings and the waste containers could be pulled out for even closer inspection. This is a well known technology (Criterion 6.12) and its performance is well demonstrated (Criterion 6.9); however, in comparison to other designs it would have a poor useful life since it is designed as a temporary facility. Even with maintenance, its effectiveness would eventually degrade as the buildings degrade (F7, F9). This facility would be easy to construct in a timely manner and the services and materials would very easy to acquire (Criteria 6.10, 6.11, & 6.13).

F.8 ENTOMBMENT

Description:

Remediation waste would be placed in 55 gallon drum containers and then placed in a concrete canister that are then sealed with grout. The canisters are then placed in a hardened concrete vault. A more detailed description of this design is given in Appendix E.

CAMU Criteria:

This would have additional features that would add to the overall but protectiveness but would come at a high cost. These protective features would include an impermeable cap, a double liner, an impermeable cap, and hardened concrete walls. Inside the facility, the waste would be further contained by placement in 55 gallon drums which in turn would be entombed in concrete canisters (Criterion 1.1). Entombment in canisters would be incorporating a treatment technology (similar to solidification) that enhances long-term effectiveness (Criterion 1.6). Due to work intensive nature of this design compared to most facilities, additional time could be needed to design and construct this facility (Criterion 1.5). Once in operation, this design would probably require more effort to get the waste from the field and into the facility and could require an additional staging area to seal the waste in concrete canisters.

Public Protection (Geotechnical and Hydrological Criteria)

Numerous barriers protect groundwater and surface water from any form of contaminant migration (Criteria 2.5, 2.11, & 2.12). Impermeable cap could have some impact on drainage patterns and infiltration (Criterion 2.11).

Site Special Issues:

Entombment would require a very large footprint because the concrete box containment takes up more space than either bulk management or cargo containers. Like other designs with concrete walls, it would be easier to place additional facilities in the vicinity of an entombment facility (Criterion 3.9). Additional staging areas would be required to grout and then place the waste containers. This could have an impact on Site activities including Site closure activities (Criterion 3.1). Additional problems could result when the waste is to be disposed of. Because the waste would be grouted into the containers, other facilities might not be willing to accept this waste. It could require expensive and time consuming reprocessing which would also have an impact to Site closure activities (Criterion 3.1).

Cost Criteria:

The Cost of Construction (Criterion 4.1) is calculated as follows:

Design	N/A
Pre-Construction	N/A
Construction	N/A
Total Cost of Construction	N/A

The Cost of Site Preparation (Criterion 4.2) is:

Cost of Site Preparation	N/A

The Cost of Closure (Criterion 4.3) is calculated as follows:

Cover	N/A
Monitoring	N/A
Final Closure	N/A
Total Cost of Closure	N/A

The above costs are combined with the costs for containers, packaging, characterization, transportation, permitting, operations, and contingency to yield the Total Life-Cycle Cost (Criterion 4.4):

Total Life-Cycle Cost	$533,800,000

* The cost for entombment was based on Idaho National Engineering Laboratory report, "Waste Management Facilities Cost Information for Mixed Low Level Waste", dated March 1994 and therefore a breakdown of costs is not available.

Entombment would be more expensive or as expensive as any of designs considered in terms of construction costs (Criterion4.1), site preparation (Criterion 4.2), closure (Criterion 4.3), and total life-cycle cost (Criterion 4.4). Factors that contribute to this high cost could include:

- Placement in concrete boxes would be labor and material intensive
- The facility itself would be very large which would increase construction costs
- The larger footprint would require more site preparation work

As with the other onsite alternatives, life cycle cost does not include the eventual cost of offsite disposal which would include retrieval, packaging, transportation and disposal costs. The inclusion of these costs would increase the total life-cycle cost significantly (by more than $150 million).

Regulatory Support:

This facility design could be considered state of the art (Criterion 5.3) due its more advanced containment system. Although the materials would be sealed in place, the concrete boxes would be retrievable for inspection (Criteria 5.3 & 5.4).

Other Stakeholder Concerns:

Retrieval of the concrete boxes themselves would be simple as long as the facility was in operation. After the placement of the cap retrieval would be more difficult. Retrieval of individual drums would be further compounded by the fact that the drums would be set in grout and would have to be chiseled out. This unit would have a long useful life and would be very effective (Criteria 6.7, & 6.9) since it would be constructed from time tested materials and would offer multiple levels of containment. Ultimately problems could occur if the entombed waste were shipped offsite since other facilities might not accept the waste in the concrete boxes. Removing the waste from the concrete boxes would be very expensive since the waste would have to be chipped out of the grout. This facility would be much more labor, material and time intensive for both construction and operation
(Criteria 6.10 & 6.11). Additional time and effort would be needed to:

- Design the facility
- Develop the technology
- Build packaging facilities
- Perform additional site preparation

The operation phase would also be more intensive due to the additional efforts required to prepare the waste in concrete canisters (Criteria 6.10 & 6.11). There could also be some problems encountered with the availability of the needed technology since this type of facility is not as common (Criterion 6.12). No problems are expected in getting the needed raw materials and services (Criterion 6.13). There could be some limitations in accepting some waste due to the size limitations of the 55 gallon drums (Criterion 6.8).

F.9 PYRAMID DESIGN

Description:

Bulk remediation waste would be placed inside of a giant hollow pyramid constructed of quarried stone blocks. A more detailed description of this design is given in Appendix E.

CAMU Criteria:

This design could require more maintenance to maintain its protectiveness since settling or shifting of the outside block could cause areas of exposure requiring repair (Criterion 1.1). A more lengthy design and construction period could be required for development of this technology and because availability of materials could be limited (Criterion 1.5).

Public Protection (Geotechnical and Hydrological Criteria)

The Pyramid design should provide good drainage based on its geometry but could alter area drainage and infiltration patterns (Criterion 2.11). The pyramid design would have to account for weight of the facility as well as impacts to slope stability (Criterion 2.3).

Site Special Issues:

This alternative could need additional design and construction time which would impact cleanup efforts under the Site Vision (Criterion 3.1). This additional time would be utilized for technology development since this is a new application. Additional time would also be spent obtaining a supplier of stone blocks, having the blocks cut, and for geotechnical work. As an innovative design, some additional time could also be required to verify the soundness of the technology. Ultimately, this could potentially impact building deactivation, decontamination, and decommissioning activities (Criteria 3.5, & 3.6). The prolonged design and construction of the facility could cause additional remediation waste to be placed in RCRA storage units consuming space needed for other waste (Criterion 3.7). There could be some problems with locating future waste facilities near the pyramid since changes in geometry of the facility are limited and the footprint is larger than other designs (Criterion 3.9).

Cost Criteria:

The Cost of Construction (Criterion 4.1) is calculated as follows:

Design	$2,200,000
Pre-Construction	$400,000
Construction	$57,900,000
Total Cost of Construction	$60,500,000

The Cost of Site Preparation (Criterion 4.2) is:

Cost of Site Preparation	$14,500,000

The Cost of Closure (Criterion 4.3) is calculated as follows:

Cover	N/A
Monitoring	$13,900,000
Final Closure	$1,500,000
Total Cost of Closure	$15,400,000

The above costs are combined with the costs for containers, packaging, characterization, transportation, permitting, operations, and contingency to yield the Total Life-Cycle Cost (Criterion 4.4):

Total Life-Cycle Cost	$141,800,000

Although this design would be one of the more expensive designs to prepare the site for and construct (Criteria 4.1 & 4.2), it would be one of the least expensive to close (Criterion 4.3) and the total life cycle cost would place this design in the lower part of the range of those considered (Criterion 4.4). Because the design is untested, additional costs could be incurred due technology development and additional design. These costs were not incorporated into the estimate. As with the other onsite alternatives, life cycle cost does not include the eventual cost of offsite disposal which would include retrieval, packaging, transportation and disposal costs. The inclusion of these costs would increase the total life-cycle cost significantly (by more than $150 million).

Regulatory Support:

Although it is an innovative design, it is not currently state of the art (Criterion 5.3) since the technology has never been developed for this application. Nor would the facility offer "the greatest degree of future applicability and utility" since it would be designed specifically for one use, the containment of contaminated soils.

Other Stakeholder Concerns:

Due to its innovative nature, a lot of unknowns are associated with this design. Although there is demonstrated performance with pyramids by ancient man for observatories, temples, or tombs, in general, there is no demonstrated performance for this particular design nor with the application of this design to waste management (Criterion 6.9). If the blocks were to remain intact, the life of the structure itself could be similar to ancient pyramids. It is not known whether differential settling would open up the seams between the blocks allowing precipitation into the interior. Depending on their size and type of stone used, the blocks for the pyramid could be difficult to acquire (Criteria 6.11, 6.12, & 6.13).

F.10 WASTE PILE

Description:

Bulk waste would be compacted into a rectangular pile, sealed in a geomembrane and covered with dirt. The facility would be underlain with a liner and leachate collection system. A more detailed description of this design is given in Appendix E.

CAMU Criteria:

Because the necessary design and site preparation of this facility would be minimal, use of the facility could be available sooner which could expedite some near-term early actions (Criterion 1.5).

Public Protection (Geotechnical and Hydrological Criteria)

The design life of this facility is to approximately 30 years. At the end of its useful life, the facility would have to modified, a new facility would have to be constructed or the waste would have to be sent to another facility (Criterion 2.1).

Site Special Issues:

The impermeable cap could be tied into the cap planned for the Industrial Area as part of Site closures activities under the Site Vision (Criterion 3.1).

Cost Criteria:

The Cost of Construction (Criterion 4.1) is calculated as follows:

Design	N/A
Pre-Construction	N/A
Construction	N/A
Total Cost of Construction	N/A

The Cost of Site Preparation (Criterion 4.2) is:

Cost of Site Preparation	N/A

The Cost of Closure (Criterion 4.3) is calculated as follows:

Cover	N/A
Monitoring	N/A
Final Closure	N/A
Total Cost of Closure	N/A

The above costs are combined with the costs for containers, packaging, characterization, transportation, permitting, operations, and contingency to yield the Total Life-Cycle Cost (Criterion 4.4):

Total Life-Cycle Cost	$36,969,000

* A breakdown of specific costs are not available. Life-cycle costs are based on actuals from a similar facility.

The construction costs and site preparations costs would be very low (Criteria 4.1 & 4.2), resulting in a a low life-cycle cost (Criterion 4.4). As with the other onsite alternatives, life cycle cost does not include the eventual cost of offsite disposal which would include retrieval, packaging, transportation and disposal costs. The inclusion of these costs would increase the total life-cycle cost significantly (by more than $150 million).

Regulatory Support:

This design is geared specifically towards soil and does not support building debris or containerized storage and therefore this facility would not have many other uses (Criterion 5.4).

Other Stakeholder Concerns:

The useful life of this facility would be limited since the intent is to provide safe, cost-effective storage until the waste can be moved to a more permanent facility (Criteria 6.6 & 6.9). The simplicity of this facility would allow for a reduced design and construction period (Criterion 6.11). Because waste would be placed in an easily accessed pile, operations would also be facilitated by this design. Once the waste pile is covered over, retrieval and monitoring of individual waste streams would be hampered by access problems and a lack of separation. On the other hand, retrieval of all of the waste at once could be relatively simple since the cover could be breached and the waste could be removed with a front end loader.

F.11 NO ACTION

Description:

The no action alternative is to shipped the waste to an offsite facility as it is generated. A more detailed description of this design is given in Appendix E and Appendix B.

CAMU Criteria:

CAMU criteria are not applicable to this action since an offsite facility would not be used as a CAMU.

Public Protection (Geotechnical and Hydrological Criteria)

Public protection would be dependent on the facility. Protection to the groundwater would likely be equivalent or better than RCRA Title C Landfill requirements. Offsite facilities could have less permeable geologic strata to meet minimum permeability of 10^{-7} centimeters/second, whereas onsite facility would likely meet the same minimum permeability with engineered barriers (Criterion 2.5).

Site Special Issues:

This option would only require a staging area for packaging and transporting the waste. Since no space would be needed for a storage facility, this option would well address the Site Vision objective of reducing the footprint of contaminated areas (Criterion 3.1). Delays in shipping could cause valuable RCRA storage space to be utilized (Criterion 3.7).

Cost Criteria:

The Cost of Construction (Criterion 4.1) is calculated as follows:

Design	N/A
Pre-Construction	N/A
Construction	N/A
Total Cost of Construction	N/A

The Cost of Site Preparation (Criterion 4.2) is:

Cost of Site Preparation	N/A

The Cost of Closure (Criterion 4.3) is calculated as follows:

Cover	N/A
Monitoring	N/A
Final Closure	N/A
Total Cost of Closure	N/A

Total Life-Cycle Cost	$0[1]

1) Minimal additional site inspection and monitoring might be required.

No-action has no costs associated with it. This assumes that staging and handling would be done at the remediation site or with existing facilities. Life-cycle costs do not include the cost of offsite disposal which would include retrieval, packaging, transportation and disposal costs. This option is the least expensive of those considered.

Regulatory Support:

Since neither a disposal facility or a RWSF in a CAMU would be constructed, permitting or regulatory requirements should be met (Criterion 5.3). Since the waste would leave the site sooner, CDPHE concerns about the disposal of radioactive waste on-site may also be alleviated (Criterion 5.5). Cleanup milestones might be impacted.

Other Stakeholder Concerns:

Cleanup could be delayed. Because this option would utilize an existing facility, issues associated with construction and the availability of the technology, materials, and services do not exist (Criteria 6.10, 6.12, & 6.13). Some offsite facilities might not be able to accept all of the waste types that would be generated due permit or license restrictions, differing waste acceptance criteria, or restrictions based on regulation (Criterion 6.8). During the operation phase, there would be delays in putting waste in the facility due to characterization, documentation, packaging, and acceptance requirements. Remediation waste would be put in temporary storage at the RFETS while these requirements were being addressed. Cost issues would need to be addressed against risk reduction capabilities.

FORWARD:

This document was developed in the early spring of 1996. The intent was to define a typical waste stream based on actual analytical data in the site characterization database (Rocky Flats Environmental Data System). Since significant data gaps exist in the characterization of the Industrial Area, data from the solar ponds characterization was used to estimate a representative waste stream. No inferences should be made regarding actual waste streams which will be activity specific and subject to regulatory agency approval. The use of waste streams such as pondcrete and solar ponds vadose zone soils were for the sole purpose of estimating typical waste streams at RFETS.

Appendix G is a report titled "Estimation Of Contaminant Concentrations From Probable Leachate Compositions At Seep Pathways In The Vicinity Of The Waste Management Facility, Rocky Flats Environmental Technology Site, Colorado."

Appendix A of this report , consisting of two reports as supporting documentation starts on page G-20.

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ESTIMATION OF CONTAMINANT CONCENTRATIONS FROM PROBABLE LEACHATE COMPOSITIONS AT SEEP PATHWAYS IN THE VICINITY OF THE WASTE MANAGEMENT FACILITY, ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE, COLORADO

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April 12, 1996

1.0 INTRODUCTION

A Waste Management Facility (WMF) has been proposed to be constructed at the Rocky Flats Environmental Technology Site (RFETS). A conceptual level, semi-quantitative assessment of the maximum level of contamination that could migrate from the Waste Management Facility (WMF) to surface water was performed. This effort serves as part of the analysis of the facility design in terms of CAMU protectiveness requirements and Part 2 Siting criteria. This report presents an estimate of the concentrations that could result from groundwater exiting from seeps and/or entering surface water from the WMF, given the current design.

Based on preliminary design drawings from RMRS/Engineering, the WMF will consist of a concrete slab, 500 by 360 feet in plan (approximately 4.13 acres). The slab will be constructed as three modules (500 feet long by 120 feet wide), which will be separated from each other by vertical concrete walls (18 feet high). A 14 foot high perimeter wall will enclose the entire slab. Various waste materials will be placed in the bins, including bulk wastes (contaminated soils), pondcrete (low strength concrete in approximately one meter cubes), and structural steel.

In concept, the bottom of the slab will be poured at existing grade. However, the slab will be underlain by a composite liner system consisting of one foot of drainage gravel, a geotextile, an 80 mil textured HDPE geomembrane, a geotextile, a geonet leak detection layer, a geotextile, an 80 mil textured HDPE geomembrane, and three feet of compacted clay.

After the various bins are filled with waste, a composite cover system will be constructed. The cover will include (from the top) two feet of vegetated soil with armament, a geotextile, one foot of graded gravel, three feet of riprap (biotic barrier), a geotextile, one foot of sand, a geotextile, an 80 mil HDPE geomembrane, a geosynthetic clay membrane, and two feet of compacted clay. Three leachate flux scenarios are addressed in this document. Scenario 1 uses a leachate flux resulting from a capped and lined WMF, representing a post-closure time period. Scenario 2 uses a leachate flux from an uncapped, but lined WMF prior to closure. The leachate flux for these scenarios are estimated using a computer model. Scenario 3 is a worst case scenario, using a leachate flux equal to an assumed RFETS recharge rate of 1 inch per year.

2.0 METHODOLOGY

A simple dilution calculation is used to obtain potential concentrations of groundwater exiting at seeps or entering surface water. In order to estimate the contamination concentrations of groundwater at locations where it intercepts surface water, (at seeps or the drainages) the following methodology was used:

1. Estimate leachate concentrations;
2. Estimate flux of leachate though the base of the WMF;
3. Estimate mass of leachate constituents in leachate exiting WMF;
4. Estimate concentrations of leachate constituents after mixing in groundwater below WMF.

In order to complete this analysis, the following assumptions were made:

- instantaneous mixing of leachate in groundwater below WMF
- annual flux out of WMF base is at equilibrium conditions (it does not change with time)
- groundwater concentrations beneath WMF do not include existing contamination
- retardation is ignored
- no thorough flow of groundwater beneath the WMF
- contamination from the WMF leachate does not "build up" over time

- concentrations are estimated for a time period after the WMF has been capped.

3.0 ESTIMATION OF LEACHATE CONCENTRATIONS

In order to estimate the concentrations of contaminants at seep locations near the WMF, it is necessary to estimate the probable leachate composition. To accomplish this, the commonly used soil/water partitioning equation (EPA, 1994) was used to estimate maximum concentrations for organic constituents and the leachate composition from Siders (1996) was used for metals and radionuclides.

The soil/water partitioning equation is a more simplified approach than numerical transport modeling. Based on the unknowns regarding the analysis parameters (amount of waste in place, contaminant concentrations in the waste, etc.) a more simplified approach is more appropriate. The soil/water partitioning equation describes the partitioning of a contaminant between solid, liquid, and gaseous phases under equilibrium conditions. The soil/water partitioning equation is:

$$C_w = C_s/[K_d + (\theta_w + \theta_a H')/\rho_b]$$

where:

C_w is the soil water concentration (mg/l)

C_s is the waste soil contaminant concentration (mg/kg)

K_d is the distribution coefficient (ml/kg)

θ_w is the water filled porosity of the waste soils (assumed to be 1.0)

θ_a is the air-filled porosity of the waste soils (assumed to be 0.0)

H' is the Henry's Law constant

ρ_b is the representative bulk density of the waste soils (assumed to be 1.5 g/cm^3)

Leachate concentrations for volatile and semi-volatile organic compounds (VOC/SVOCs) contaminants were estimated by Roberts (1996) with greater than 15% detection frequency. These VOC/SVOC leachate concentrations were used in this analysis for the initial leachate concentrations and composition for VOC/SVOCs. Roberts calculated K_d values for the VOC/SVOCs using site-specific data. Roberts (1996) estimation of VOC/SVOC leachate composition and concentrations are presented in Table 1.

A similar approach (using the soil/water partitioning equation) was initially planned for estimating the leachate composition and concentrations for metals and radionuclides. Examination of K_d values for metals and radionuclides (used in the soil/water partitioning equation) revealed virtually no site specific values and that literature values ranged over several orders of magnitude. This variability makes it much more difficult to derive K_ds for metals than VOC/SVOCs. EPA (1994) indicates that the K_ds for metals (and metallic radionuclides) are affected by several factors, including numerous geochemical processes and parameters, variability in the field, and differences in experimental methods. These factors result in variabilities of up to seven orders of magnitude.

Because no meaningful literature or site-specific values for metal K_ds could be obtained, the leachate composition derived by Siders (1996) was used. Siders calculated a probable leachate compositions for metals, radionuclides, and inorganic parameters based on estimated volumes of waste to be stored in the WMF and available data for leachates, pore water, and groundwater from wastes and waste areas. Siders (1996) estimated metals and radionuclides leachate composition and concentrations are also presented in Table 1.

Roberts (1996) and Siders (1996) are contained in Appendix A as supporting documentation.

4.0 ESTIMATION OF LEACHATE FLUX

In order to estimate the amount of contaminants that could potentially reach surface water from the WMF, it was necessary to estimate the flux of fluid through the base of the WMF. This was accomplished using the results of two Hydrologic Evaluation of Landfill Performance (HELP) models and an assumed value of leachate flux. The HELP numerical code was developed for the EPA by the

U.S. Army Corps of Engineers. HELP is used to obtain rapid and economical estimation of water flux in and out of landfills. Both site-specific and literature values were used in the preparation of this model, which was used to evaluate the effectiveness of the proposed WMF cap/liner system design. The model was run for 100 years.
The HELP model for the WMF consisted of 17 layers over a 10 acre site, representing the engineered liner and cap system. The layers are:

Layer 1 - angular pea gravel

Layer 2 - vegetative layer with gravel

Layer 3 - general backfill

Layer 4 - sand/gravel

Layer 5 - bioexclusion layer (cobbles)

Layer 6 - sand/gravel

Layer 7 - geomembrane and geosynthetic clay liner

Layer 8 - clay liner

Layer 9 - general backfill

Layer 10 - compacted waste

Layer 11 - drainage network

Layer 12 - concrete slab with drainage pipes

Layer 13 - gravel

Layer 14 - leachate collection membrane

Layer 15 - geocomposite

Layer 16 - leak detection membrane

Layer 17 - barrier soil liner (clay).

To evaluate a range of possibilities regarding leachate fluxes, three scenarios were examined. Two scenarios using HELP were examined. Scenario 1 includes both cap and liner systems (simulating post-closure), while Scenario 2 includes only the liner system with no cap(simulating pre-closure).

Another scenario (Scenario 3) was also considered in which the leachate flux through the base of the WMF is equal to an assumed recharge rate at RFETS (1 inch/year). Scenario 3 would represent a worst-case scenario because in order for this scenario to take place, the cap/liner system would either have experienced complete failure or would have never been installed. It should be noted that the assumed recharge rate is probably greater than the actual value at Rocky Flats.
From the HELP model scenarios, the average annual leakage through the base of layer 17 (the bottom clay liner) is 0.084 ft^3 (2.38 liters) for Scenario 1 (cap and liner) and 0.205 ft^3 (5.81 liters) for Scenario 2 (liner). These fluxes are probably greater than what would actually result from the WMF, due to the differences in the areas for the HELP models (10 acres) and the proposed design (4.13 acres). This is a conservative result because it would introduce more leachate into the groundwater. This results are only valid for the various inputs used in the model, including industry standard parameters, literature values, and the proposed design of the WMF. Any changes in the model parameter values could change the results of the model. Of course, the model is only a predictor of ideal conditions. Actual design and construction of the WMF will affect performance. It is assumed that the amount of leachate exiting the WMF is continuous and at equilibrium (it will not change with time). The HELP model output is contained in Appendix B.

USING THE ASSUMED VALUE OF SITE RECHARGE (1 INCH/YEAR) AND THE SAME AREA USED IN THE HELP MODEL (10 ACRES) RESULTS IN 36,300 FT^3 (1.03 MILLION LITERS) OF LEACHATE EXITING THE WMF ANNUALLY. AGAIN, THIS SCENARIO REPRESENTS A WORST-CASE SCENARIO WHICH COULD ONLY RESULT FROM EITHER NO CAP/LINER INSTALLATION OR COMPLETE FAILURE OF THE CAP/LINER SYSTEM.

5.0 ESTIMATION OF MASS/ACTIVITY OF LEACHATE CONSTITUENTS

Using the flux exiting the WMF estimated in section 4.0, the mass (or activities for the radionuclides) of the leachate constituents were calculated. This was accomplished by multiplying the amount of the annual flux for each scenario (2.38, 5.81, and 1.03 million liters for scenarios 1, 2, and 3, respectively) by the concentration of the constituents comprising the leachate. The results of this calculation are presented in Table 2. These results represents the mass/activities of contaminants available for mixing in groundwater below the WMF.

6.0 ESTIMATION OF GROUNDWATER VOLUME BELOW WMF

To calculate the resulting concentrations of the mass/activity of leachate constituents, it is necessary to estimate the volume of groundwater beneath the WMF. To obtain this volume, the average saturated thickness was estimated, based on water levels wells screened in the upper hydrostratigraphic unit (UHSU). These data are available in EG&G (1995a). Since the UHSU is comprised of both alluvial materials and weathered bedrock, the estimated saturated thickness included the thickness of the weathered bedrock. The thickness of the weathered bedrock was obtained from EG&G (1995b). Using a saturated thickness of approximately 35 feet, a porosity of 0.3, and an assumed area of 10 acres, there is approximately 130 million liters of groundwater beneath the WMF available for mixing.

7.0 ESTIMATION OF GROUNDWATER CONCENTRATIONS BENEATH WMF FROM LEACHATE

Using the volume of groundwater beneath the WMF (estimated in section 6.0) and the mass/activity of the leachate constituents (estimated in section 5.0), the concentration of the groundwater from leachate constituents is calculated for each scenario. This is accomplished by dividing the volume of groundwater by the mass/activity of the constituents. This assumes instantaneous mixing of the leachate and the groundwater beneath the WMF and instantaneous appearance at surface water points and seeps. This is a conservative assumption, since no retardation and decay of the contaminants is considered. Concentrations of the leachate constituents which already exist (either naturally or through anthropogenic agencies) in the groundwater are not considered.

This estimation, however, does not consider the addition of contaminants over time. Table 3 presents the potential concentrations of groundwater beneath the WMF from leachate for each scenario. These concentrations represent a potential value for groundwater exiting at seeps and entering surface water for the given scenarios.

8.0 CONCLUSIONS AND RECOMMENDATIONS

These estimates represent potential concentrations for groundwater contamination from leachate. Assuming that this concentration reaches the surface water and seeps, it also represents a potential concentration that could appear at these locations. Resulting groundwater concentrations for the three scenarios were compared to draft RFCA (RFCA, 1996) action levels for surface water as a mean of evaluating the impact of the WMF. Table 4 lists the applicable RFCA surface water action levels for stream segment 5 (the section of Walnut Creek near the WMF).

Any modifications to the existing HELP model and/or changes in the design of the WMF could result in changes to the concentrations obtained in this analysis. Actual construction of the WMF could also result in differences between the predicted concentrations and observed concentrations in the future.

8.1 Scenario 1 (Cap and Liner)

The predicted concentrations, when compared with applicable surface water action levels listed in the draft RFCA, are much less than those levels requiring action. Because the estimated concentrations are very low, it appears that the design of the cap/liner system (as used in the HELP model) is sufficient to protect surface water and seeps from contamination.

It should be noted that changing the saturated thickness from 35 feet to 5 feet (thickness of the alluvial part of the UHSU) will lessen the resulting volume by less than an order of magnitude. Thus, reduction in the saturated thickness will only increase the resulting concentrations by an order of magnitude. These values would still be well below the actions levels specified by RFCA.

8.2 Scenario 2 (Liner)

Comparison of the resulting concentrations for Scenario 2 with RFCA surface water action levels reveals that for most leachate constituents, the concentrations are less than the action levels. Because the estimated concentrations are very low, it appears that during the active life of the facility, while waste is being loaded into the WMF modules, the liner system is sufficient to protect surface water and seeps from contamination.

Changing the saturated thickness from 35 feet to 5 feet (the thickness of the alluvial part of the UHSU) will lessen the resulting volume by less than an order of magnitude, thus increasing the groundwater concentrations by an order of magnitude. This action would not increase groundwater concentration above RFCA action levels for surface water.

8.3 Scenario 3 (Flux equals Recharge)

Comparison of the resulting concentrations for Scenario 3 with RFCA surface water action levels reveals that for most leachate constituents, the concentrations are less than the action levels. Only for certain VOC/SVOCs (carbon tetrachloride, 1,1 dichloroethane, 1,2 dichloroethene, methylene chloride, tetrachloroethylene, and trichloroethene) are groundwater concentrations greater than RFCA action levels for surface water. It should be noted that this scenario is the worst-case scenario. This scenario is not likely to take place because a liner would restrict leachate percolation into the UHSU. This scenario would either represent a complete failure of the cap/liner system or no cap/liner.

It should be noted that changing the saturated thickness from 35 feet to 5 feet (thickness of the alluvial part of the UHSU) will lessen the resulting volume by less than an order of magnitude, thus increasing the groundwater concentrations by an order of magnitude. This modification would lead to a greater number of leachate constituents exceeding the draft RFCA surface water action levels. In addition to the VOC/SVOCs mentioned previously, bis (2-ethylhexyl) phthalate exceeds the draft RFCA surface water action levels, as do some metals (manganese, mercury, and silver) and radionuclides (gross alpha, gross beta, U-233/234, and U-238).

8.4 Recommendations

It is recommended that a transport model, using the fluxes obtained from the HELP model and the leachate concentrations from Roberts (1996) and Siders (1996). A numerical model could incorporate retardation and decay, as well as account for mass transfer from the groundwater system to the surface water and seeps. It may be possible to utilize the ASAP groundwater flow model, once it is calibrated. The ASAP modeling effort is anticipated to be calibrated by the end of August 1996. It is also recommended that a three-dimensional scientific visualization be constructed of the area where the WMF is to be constructed. RMRS Environmental Restoration has the capability to perform this task, which would show the relationships of geology and hydrogeology with the WMF. A three-dimensional model would be invaluable for integrating data and interpretations and would be useful for both technical and non-technical personnel.

9.0 REFERENCES

EG&G, 1995a, Hydrogeologic characterization report for the Rocky Flats Environmental Technology Site, Volume II of the sitewide geoscience characterization study, EG&G Rocky Flats, Golden, Colorado.

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Roberts, B., 1996, Calculation of probable maximum leachate concentrations, memorandum to E. Mast, February 1, 1996.

Rocky Flats Cleanup Agreement (RFCA) (Public Comment Draft), March 14, 1996.

Siders, M., 1996, Analysis of inorganic constituents and probable leachate composition from waste stored in the new waste cell at the Rocky Flats Environmental Technology Site, Golden, Colorado, Rocky Mountain Remediation Services, March 29, 1996.

TABLES

Table 1: Estimated Leachate Concentrations

Constituent	Leachate Concentrations	Units
Volatile Organic Compounds		
Acetone	150000	µg/L
Carbon Tetrachloride	2100	µg/L
Chloroform	3000	µg/L
1,1 Dichloroethane	3100	µg/L
1,1 Dichloroethene	2800	µg/L
1,2 Dichloroethene	16000	µg/L
Diethyl Phthalate	12000	µg/L
Di-n-Butyl Phthalate	3600	µg/L
Bis (2-Ethylhexyl) Phthalate	140	µg/L
Methylene Chloride	19000	µg/L
Tetrachloroethylene	2000	µg/L
1,1,1-Trichloroethane	2500	µg/L
Trichloroethene	2500	µg/L
Metals		
Aluminum	547	µg/L
Antimony	22	µg/L
Arsenic	48	µg/L
Barium	133	µg/L
Beryllium	1.8	µg/L
Cadmium	8.5	µg/L
Calcium	111230	µg/L
Cesium	146	µg/L
Chromium	173	µg/L
Cobalt	37	µg/L
Copper	59	µg/L
Iron	970	µg/L
Lead	27	µg/L
Lithium	528	µg/L
Magnesium	17910	µg/L
Manganese	550	µg/L
Mercury	0.46	µg/L
Molybdenum	302	µg/L
Nickel	90	µg/L
Potassium	165300	µg/L
Selenium	5.5	µg/L

Table 1 (cont.)
Estimated Leachate Concentrations

Constituent	Leachate Concentrations	Units
Silver	10	µg/L
Sodium	783800	µg/L
Strontium	1640	µg/L
Thallium	8	µg/L
Tin	84	µg/L
Vanadium	17	µg/L
Zinc	60	µg/L
Radionuclides		
Americium-241	0.11	pCi/L
Cesium-134	ID	pCi/L
Cesium-137	0.33	pCi/L
Gross Alpha	375	pCi/L
Gross Beta	230	pCi/L
Plutonium-239/240	0.12	pCi/L
Radium 226	1.4	pCi/L
Radium-228	3.2	pCi/L
Tritium (total)	1310	pCi/L
Uranium-233/234	147	pCi/L
Uranium-235	6.1	pCi/L
Uranium-238	142	pCi/L

Notes:

ID = Insufficient Data
µg/L = micrograms per liter
pCi/L = picocuries per liter

Table 2: Estimated Mass/Activity of Leachate Constituents Exiting WMF

Constituent	Scenario 1	Scenario 2	Scenario 3	Units
Volatile Organic Compounds				
Acetone	357000	871500	1.54E+11	µg
Carbon Tetrachloride	4998	12201	2.16E+09	µg
Chloroform	7140	17430	3.09E+09	µg
1,1 Dichloroethane	7378	18011	3.19E+09	µg
1,1 Dichloroethene	6664	16268	2.88E+09	µg
1,2 Dichloroethene	38080	92960	1.65E+10	µg
Diethyl Phthalate	28560	69720	1.24E+10	µg
Di-n-Butyl Phthalate	8568	20916	3.70E+09	µg
Bis (2-Ethylhexyl) Phthalate	333.2	813.4	1.44E+08	µg
Methylene Chloride	45220	110390	1.96E+10	µg
Tetrachloroethylene	4760	11620	2.06E+09	µg
1,1,1-Trichloroethane	5950	14525	2.57E+09	µg
Trichloroethene	5950	14525	2.57E+09	µg
Metals				
Aluminum	1301.86	3178.07	5.60E+08	µg
Antimony	52.36	127.82	2.26E+07	µg
Arsenic	114.24	278.88	4.94E+07	µg
Barium	316.54	772.73	1.37E+08	µg
Beryllium	4.284	10.458	1.85E+06	µg
Cadmium	20.23	49.39	8.75E+06	µg
Calcium	264727.4	646246.3	1.15E+11	µg
Cesium	347.48	848.26	1.50E+08	µg
Chromium	411.74	1005.13	1.78E+08	µg
Cobalt	88.06	214.97	3.81E+07	µg
Copper	140.42	342.79	6.05E+07	µg
Iron	2308.6	5635.7	19.95E+08	µg
Lead	64.26	156.87	2.78E+07	µg
Lithium	1256.64	3067.68	5.45E+08	µg
Magnesium	42625.8	104057.1	1.84E+10	µg
Manganese	1309	3195.5	5.65E+08	µg
Mercury	1.0948	2.6726	4.73E+05	µg
Molybdenum	718.76	1754.62	3.11E+08	µg
Nickel	214.2	522.9	9.25E+07	µg
Potassium	393414	960393	1.70E+11	µg
Selenium	13.09	31.955	5.56E+06	µg

Table 2 (cont.)
Estimated Mass/Activity of Leachate Constituents Exiting WMF

Constituent	Scenario 1	Scenario 2	Scenario 3	Units
Silver	23.8	58.1	1.03E+07	µg
Sodium	1865444	4553878	8.05E+11	µg
Strontium	3903.2	9528.4	1.69E+09	µg
Thallium	19.04	46.48	8.20E+06	µg
Tin	199.92	488.04	8.65E+07	µg
Vanadium	40.46	98.77	1.75E+07	µg
Zinc	142.8	348.6	6.15E+07	µg
Radionuclides				
Americium-241	0.2618	.6391	1.13E+05	pCi
Cesium-134	ID	ID	ID	pCi
Cesium-137	0.7854	1.9173	3.40E+05	pCi
Gross Alpha	892.5	2178.75	3.86E+08	pCi
Gross Beta	547.4	1336.3	2.37E+08	pCi
Plutonium-239/240	0.2856	.6972	1.24E+05	pCi
Radium 226	3.332	8.134	1.44E+06	pCi
Radium-228	7.616	18.592	3.29E+06	pCi
Tritium (total)	3117.8	7611.1	1.35E+09	pCi
Uranium-233/234	349.86	854.07	1.51E+08	pCi
Uranium-235	14.518	35.441	6.25E+06	pCi
Uranium-238	337.96	825.02	1.46E+08	pCi

Notes:

ID = Insufficient Data
Mass/Activity calculated from leachate concentrations in Table 1.
µg = micrograms (mass)
pCi = picocuries (activity)
Scenario 1 leachate flux = 2.38 liters.
Scenario 2 leachate flux = 5.81 liters.
Scenario 3 leachate flux = 1.03 million liters.

Table 3: Estimated Groundwater Concentrations Beneath WMF From Leachate

Constituent	Scenario 1	Scenario 2	Scenario 3	Units
Volatile Organic Compounds				
Acetone	2.76E-03	6.73E-03	1190	µg/L
Carbon Tetrachloride	3.86E-05	9.42E-05	16.65	µg/L
Chloroform	5.51E-05	1.35E-04	23.8	µg/L
1,1 Dichloroethane	5.70E-05	1.39E-04	24.6	µg/L
1,1 Dichloroethene	5.14E-05	1.26E-04	22.2	µg/L
1,2 Dichloroethene	2.94E-04	7.18E-04	127	µg/L
Diethyl Phthalate	2.20E-04	5.38E-04	95	µg/L
Di-n-Butyl Phthalate	6.61E-05	1.61E-04	28.55	µg/L
Bis (2-Ethylhexyl) Phthalate	2.57E-06	6.28E-06	1.11	µg/L
Methylene Chloride	3.49E-04	8.52E-04	151	µg/L
Tetrachloroethylene	3.67E-05	8.97E-05	15.85	µg/L
1,1,1-Trichloroethane	4.59E-05	1.12E-04	19.85	µg/L
Trichloroethene	4.59E-05	1.12E-04	11	µg/L
Metals				
Aluminum	1.01E-05	2.45E-05	4.34	µg/L
Antimony	4.04E-07	9.87E-07	0.175	µg/L
Arsenic	8.82E-07	2.15E-06	0.381	µg/L
Barium	2.44E-06	5.97E-06	1.06	µg/L
Beryllium	3.31E-08	8.07E-08	0.0143	µg/L
Cadmium	1.56E-07	3.81E-07	0.0675	µg/L
Calcium	2.04E-03	4.99E-03	885	µg/L
Cesium	2.68E-06	6.55E-06	1.16	µg/L
Chromium	3.18E-06	7.76E-06	1.375	µg/L
Cobalt	6.80E-07	1.66E-06	0.294	µg/L
Copper	1.08E-06	2.65E-06	0.469	µg/L
Iron	1.78E-05	4.35E-05	7.7	µg/L
Lead	4.96E-07	1.21E-06	0.215	µg/L
Lithium	9.70E-06	2.37E-05	4.19	µg/L
Magnesium	3.29E-04	8.03E-04	142	µg/L
Manganese	1.01E-05	2.47E-05	4.37	µg/L
Mercury	8.45E-09	2.06E-08	0.0037	µg/L
Molybdenum	5.55E-06	1.35E-05	2.395	µg/L
Nickel	1.65E-06	4.04E-06	0.72	µg/L
Potassium	3.04E-03	7.41E-03	1310	µg/L
Selenium	1.01E-07	2.47E-07	0.0437	µg/L
Silver	1.84E-07	4.49E-07	0.0795	µg/L

Table 3 (cont.)
Estimated Groundwater Concentrations Beneath WMF From Leachate

Constituent	Scenario 1	Scenario 2	Scenario 3	Units
Sodium	1.44E-02	3.52E-02	6200	µg/L
Strontium	3.01E-05	7.36E-05	13	µg/L
Thallium	1.47E-07	3.59E-07	0.0635	µg/L
Tin	1.54E-06	3.77E-06	0.665	µg/L
Vanadium	3.12E-07	7.63E-07	0.135	µg/L
Zinc	1.10E-06	2.69E-06	0.476	µg/L
Radionuclides				
Americium-241	2.02E-09	4.93E-09	0.0009	pCi/L
Cesium-134	ID	ID	ID	pCi/L
Cesium-137	6.06E-09	1.48E-08	.0026	pCi/L
Gross Alpha	6.89E-06	1.68E-05	2.98	pCi/L
Gross Beta	4.23E-06	1.03E-05	1.83	pCi/L
Plutonium-239/240	2.20E-09	5.38E-09	0.001	pCi/L
Radium 226	2.57E-08	6.28E-08	0.011 1	pCi/L
Radium-228	5.88E-08	1.44E-07	0.0254	pCi/L
Tritium (total)	2.41E-05	5.88E-05	10.4	pCi/L
Uranium-233/234	2.70E-06	6.59E-06	1.17	pCi/L
Uranium-235	1.12E-07	2.74E-07	0.0484	pCi/L
Uranium-238	2.61E-06	6.37E-06	1.13	pCi/L

Notes:

ID = Insufficient Data

Concentrations calculated from mass/activities in Table 3 and estimated groundwater volume of 130 million liters.

µg/L = micrograms per liter

pCi/L = picocuries per liter

Table 4: DRAFT RFCA Surface Water Action Levels for Stream Segment 5 (Walnut Creek)

Constituent	Concentration	Units
Volatile Organic Compounds		
Acetone	365000	μg/L
Carbon Tetrachloride	5	μg/L
Chloroform	100	μg/L
1,1 Dichloroethane	1010	μg/L
1,1 Dichloroethene	7	μg/L
1,2 Dichloroethene	70	μg/L
Diethyl Phthalate	29200	μg/L
Di-n-Butyl Phthalate	3650	μg/L
Bis (2-Ethylhexyl) Phthalate	6	μg/L
Methylene Chloride	5	μg/L
Tetrachloroethylene	5	μg/L
1,1,1-Trichloroethane	200	μg/L
Trichloroethene	5	μg/L
Metals		
Aluminum	8700	μg/L
Antimony	1400	μg/L
Arsenic	50	μg/L
Barium	1000	μg/L
Beryllium	4	μg/L
Cadmium	1.5	μg/L
Calcium	NAL	μg/L
Cesium	NAL	μg/L
Chromium	50	μg/L
Cobalt	NAL	μg/L
Copper	16	μg/L
Iron	300	μg/L
Lead	6500	μg/L
Lithium	NAL	μg/L
Magnesium	NAL	μg/L
Manganese	50	μg/L
Mercury	0.01	μg/L
Molybdenum	1000	μg/L
Nickel	123	μg/L
Potassium	NAL	μg/L
Selenium	10	μg/L
Silver	0.6	μg/L
Sodium	NAL	μg/L

Table 4 (cont.)
DRAFT RFCA Surface Water Action Levels for Stream Segment 5 (Walnut Creek)

Constituent	Concentrations	Units
Strontium	NAL	µg/L
Thallium	NAL	µg/L
Tin	NAL	µg/L
Vanadium	NAL	µg/L
Zinc	141	µg/L
Radionuclides		
Americium-241	0.15	pCi/L
Cesium-134	NAL	pCi/L
Cesium-137	NAL	pCi/L
Gross Alpha	10	pCi/L
Gross Beta	11	pCi/L
Plutonium-239/240	0.15	pCi/L
Radium 226	5	pCi/L
Radium-228	5	pCi/L
Tritium (total)	500	pCi/L
Uranium-233/234	10	pCi/L
Uranium-235	10	pCi/L
Uranium-238	10	pCi/L

Notes:

µg/L = micrograms per liter
pCi/L = picocuries per liter
NAL = No listed Action Level

CALCULATION OF PROBABLE MAXIMUM LEACHATE CONCENTRATIONS

To assist in the design of the leachate treatment system for the Waste Management Facility, the following analysis was performed to determine the probable maximum leachate concentrations for the major organic contaminants found at the Rocky Flats Environmental Technology Site (RFETS). For this analysis, the commonly used soil/water partitioning equation was used to determine the contaminant concentrations in interstitial water in waste soils within the Waste Cell.

Although a more in-depth approach to estimating the leachate concentrations was considered (1D vertical transport modeling), the goals of the analysis (determination of maximum expected concentrations), and the ambiguity of the analysis parameters (amount of waste in place, contaminant concentrations in waste, etc.) indicated a simplified approach would be more appropriate. Because of the simplifying assumptions that would be adopted for 1D vertical transport modeling, the results from transport modeling should be very similar to those presented here.

COMPOUNDS CONSIDERED IN ANALYSIS

To determine which volatile organic compounds (VOC) and semivolatile organic compounds (SVOC) to use in this analysis, the detection frequency for all VOC/SVOC compounds of concern at RFETS was computed. Only those compounds tested for in at least 100 samples, and with a detection frequency of at least 5% were included in the leachate concentration calculations. The compounds and their detection frequency are listed in Table 1.

TABLE 1: Compounds Used in Analysis

COMPOUNDS WITH A DETECTION FREQUENCY OF AT LEAST 5%					
COMPOUND	CAS ID	Non-detects	Detects	Total	% Detects
ACETONE	67-64-1	2713	463	3176	15
CARBON TETRACHLORIDE	56-23-5	4576	1060	5636	19
CHLOROFORM	67-66-3	4477	1177	5654	21
1,1 DICHLOROETHANE	75-34-3	5345	341	5686	6
1,1-DICHLOROETHENE	75-35-4	5215	463	5678	8
1,2-DICHLOROETHENE	540-59-0	2875	338	3213	11
DIETHYL PHTHALATE	84-66-2	552	63	615	10
DI-n-BUTYL PHTHALATE	84-74-2	569	45	614	7
BIS(2-ETHYLHEXYL)PHTHALATE	117-81-7	470	143	613	23
METHYLENE CHLORIDE	75-09-2	4607	1038	5645	18
TETRACHLOROETHENE	127-18-4	4054	1620	5674	29
1,1,1-TRICHLOROETHANE	71-55-6	5150	516	5666	9
TRICHLOROETHENE	79-01-6	4025	1653	5678	29

DETERMINATION OF LEACHATE CONCENTRATIONS

For this analysis the VOC/SVOC contaminated soils in the waste cell were considered to be directly exposed to rain and snow fall. Leachate concentrations were calculated assuming the soils at the base of the waste soil pile were saturated. This assumption is conservative and will provide maximum leachate concentrations. Drainage from unsaturated soils would result in somewhat lower concentrations.

The saturated-soil, contaminant water concentrations were calculated using the soil-groundwater partitioning equation, as presented in EPA (1994). This equation describes the partitioning of a contaminant between solid, liquid, and gaseous phases assuming equilibrium conditions. It is assumed that the concentrations of the interstitial water in the soil waste is representative of the maximum concentrations of any leachate that would be collected from the waste cell facility. Dilution from other waters collecting in the waste cell are not considered in these calculations. The soil/water partitioning equation is defined as:

$$C_w = C_s / [Kd + (\theta_w + \theta_a H') / \rho_b]$$

where:

C_w is the soil water concentration
C_s is the contaminant concentration in the waste soils
Kd is the soil-water partitioning coefficient
θ_w is the water-filled porosity of the waste soils
θ_a is the air-filled porosity of the waste soils
H' is the Henry's Law constant
ρ_b is the representative bulk density of the waste soils

The contaminant concentrations in the waste soils were assumed to be equal to the values defined by the Universal Treatment Standards (UTS) (Table 2). These values were selected because soils placed in the waste cell will be required to meet the UTS criteria. In many cases, the concentrations of contaminants in the soils placed in the cell will be significantly lower than those defined by the UTS. This is because of the efficiency of the soil treatment technology and/or low initial soil concentrations.

Because waste soils will be coming from various locations within RFETS, values representative of sitewide conditions at RFETS were used for several of the parameters during the calculations. The partitioning coefficients (Kd), which are chemical specific, were computed using the appropriate chemical specific parameters, and representative RFETS sitewide values for environmental parameters. The water filled porosity (θ_w) and soil bulk density (ρ_b) were assumed as 0.40 and 1.5 gm/cm^3 respectively. Since the soils were considered saturated, the Henry's Law constant and air filled porosity values were not used in the calculations.

Table 2 presents the computed maximum soil water (leachate) concentrations. In addition, the partitioning coefficients (Kd) and UTS soil concentration data used in the calculations are also listed. For comparison purposes the maximum soil concentration observed to date for each compound at RFETS is also listed. Contaminant concentrations greater than those historically observed may be encountered during full scale excavation of contaminant source areas.

TABLE 2: Computed Leachate Concentrations

COMPOUND	Kd	UTS Soil Concen.	Maximum RFETS Soil Concen.	Water Concen.
	(ml/g)	(mg/kg)	(mg/kg)	(mg/L)
ACETONE	0.80	160	5100	150
CARBON TETRACHLORIDE	2.5	6	25000	2.1
CHLOROFORM	1.8	6	63	3.0
1,1 DICHLOROETHANE	1.7	6	0.049	3.1
1,1 DICHLOROETHENE	1.9	6	2	2.8
1,2 DICHLOROETHENE	1.6	30	1.2	16
DIETHYL PHTHALATE	2.1	28	3.1	12
DI-n-BUTYL PHTHALATE	7.5	28	43	3.6
BIS(2-ETHYLHEXYL) PHTHALATE	198	28	190	0.14
METHYLENE CHLORIDE	1.3	30	2400	19
TETRACHLOROETHYLENE	2.7	6	13000	2.0
1,1,1-TRICHLOROETHANE	2.2	6	240	2.5
TRICHLOROETHENE	2.2	6	16	2.5

REFERENCES

EPA, 1994, Soil Screening Guidance (Draft), EPA/540/R-94/101.

ANALYSIS OF INORGANIC CONSTITUENTS AND PROBABLE LEACHATE COMPOSITION FROM WASTE STORED IN THE NEW WASTE CELL AT THE ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE, GOLDEN, COLORADO

March 29, 1996

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Rocky Mountain Remediation Services

1.0 INTRODUCTION

The composition and volume of wastes to be placed in the proposed Waste Cell at Rocky Flats Environmental Technology Site (RFETS) were evaluated as part of the preparatory analysis for design and construction of the Cell. This report presents an assessment of the inorganic constituents in the waste, as well as estimations of the probable composition of leachate that may emanate from wastes stored in the Cell.

Wastes to be disposed of in the Cell include a variety of materials from a number of Operable Units (OUs) at RFETS. The estimated proportions, by volume, of waste to be placed in the cell are as follows:

OU4 vadose-zone soils	24.1%
OU4 pondcrete	14.5%
OU2 903 Pad and Lip	14.5%
OU4 asphalt liners	14.2%
OU4 subgrade & subsoils	14.2%
OU4 sludge	7.2%
OU9 tanks 14 & 16	4.0%
OU2 mound area	1.8%
OU2 trenches T-5 to T-11	1.2%
OU2 trench T-1	1.2%
OU4 debris	0.8%
OU9 tanks 9 & 10	0.6%
OU2 trench T-3	0.3%
OU2 trench T-4	0.3%
OU10 tank 40	0.2%
IDM wastes	0.2%
OU1 IHSS 119.1	0.1%
Misc. hot spots	0.1%

Chemical analyses of solid materials and groundwater from these areas, in addition to analytical data for leachates derived from Operable Unit 4 (OU4) pondcrete and sludges, were compiled and evaluated for this assessment. Data used in this analysis were retrieved from the Rocky Flats Environmental Database System (RFEDS) and from treatability reports for OU4 pondcrete and sludges. Only data for inorganic constituents are evaluated here; data for organic compounds were evaluated as a separate task.

Analytical data for subsurface soils (i.e., borehole data) and groundwater were obtained from RFEDS. These data were compiled as SAS7 data sets, prepared following standard data-cleanup protocols, and statistically summarized. Locations for which borehole and groundwater data were available are listed in Tables 1 and 2, respectively.

Table 1.
Sampling Locations with Data Available for Subsurface Soils

Metals		Radionuclides		"'Water-Quality"	
02695	13091	02695	13091	02695	13091
02795	21793	02795	21793	02795	21793
02895	40293	02895	40293	02895	40293
02995	40393	02995	40393	02995	40393
04795	40593	04795	40593	*	40593
04895	40793	04895	40793	*	40793
04995	40993	04995	40993	*	40993
05095	41293	05095	41293	*	41293
06591	41593	06591	41593	06591	41593
06691	41793	06691	41793	06691	41793
06791	42193	06791	42193	06791	42193
06891	42493	06891	42493	06891	42493
06991	42593	06991	42593	06991	42593
07091	43193	07091	43193	07091	43193
07191	43393	07191	43393	07191	43393
07291	43693	07291	43693	07291	43693
07391	43793	07391	43793	07391	43793
07891	44093	07891	44093	07891	44093
07991	44393	07991	44393	07991	44393
08091	B217589	08091	B217589	08091	B217589
08191	BH2287	08191	BH2287	08191	BH2287
08291	BH2387	08291	BH2387	08291	BH2387
08391	BH2487	08391	BH2487	08391	BH2487
08491	BH3587	08491	BH3587	08491	BH3587
08591	BH3687	08591	BH3687	08591	BH3687
08691	BH3787	08691	BH3787	08691	BH3787
08791	BH3987	08791	BH3987	08791	BH3987
08891	BH4087	08891	BH4087	08891	BH4087
08991	BH4287	08991	BH4287	08991	BH4287
09091	BH4387	09091	BH4387	09091	BH4387
09191	BH4687	09191	BH4687	09191	BH4687
09391	BH4887	09391	BH4887	09391	BH4887
09591	BH4987	09591	BH4987	09591	BH4987
09891	BH5087	09891	BH5087	09891	BH5087
09991	BH5187	09991	BH5187	09991	BH5187
10191	BH5287	10191	BH5287	10191	BH5287
10291	BH5387	10291	BH5387	10291	BH5387
10491	BH5487	10491	BH5487	10491	BH5487
10591	BH5587	10591	BH5587	10591	BH5587

Asterisk (*) indicates that data were not available for this location.

Table 2.
Sampling Locations with Data Available for Groundwater Samples

Metals		Radionuclides		Water-Quality
Dissolved	Total	Dissolved	Total	Unfiltered *
*	*	*	*	02695
*	*	*	02795	02795
*	02895	*	*	02895
*	*	*	02995	02995
*	*	*	*	04795
*	*	*	*	04895
*	*	*	*	04995
06591	06591	06591	06591	06591
06691	06691	06691	06691	06691
06791	06791	06791	06791	06791
06891	06891	06891	06891	06891
06991	06991	06991	06991	06991
*	*	*	*	*
07191	07191	07191	07191	07191
07291	*	07291	07291	07291
07391	07391	07391	07391	07391
07891	07891	07891	07891	07891
07991	07991	07991	07991	07991
*	*	08091	08091	08091
*	*	*	*	08391
*	*	*	*	08591
08891	08891	08891	08891	08891
09091	09091	09091	09091	09091
13091	13091	13091	13091	13091
B217589	*	B217589	B217589	B217589

Asterisk (*) indicates that data were not available for this location.
* Samples collected for analysis of anions and water-quality paramters are not filtered; however, anions are assumed to exist in the dissolved state.

Data for OU4 vadose-zone waters were obtained from tables in the *OU4 Proposed IM/IRA EA Decision Document*, dated February 10, 1995 (EG&G, 1995a). Data for OU4 pondcrete and sludges were available in *Treatability Study Report and Process Formulation Report for Pondcrete* (EG&G, 1995b) and *Treatability Study Report and Process Formulation Report for Pond Sludge and Clarifier* (EG&G, 1995c). Unfortunately, the data presented in these treatability studies do not include major-ion compositions of the leachates; only data for selected radionuclides and trace metals, nitrate, and pH are given. Without major-ion data, standard geochemical modeling cannot be performed for the pondcrete and sludge leachates.

2.0 DATA ANALYSIS

Standard data-treatment protocols for RFEDS data call for the exclusion of QC data from the real-sample data, removal of rejected data (validation code = "R"), and the standardization of units and analyte names. Computation of summary statistics used a simple replacement value of one-half the result for nondetects. One-half the result was used instead of one-half the detection limit, in order to minimize the problems associated with high-value detection limits (i.e., the contract-required reporting limits [CRDL]) reported in the detection-limit field for some records.

Because distributional testing was not performed, these summary statistics should be considered only a general approximations of the true mean. In addition, the user should be cognizant of the detection rate for each analyte; as the detection rate decreases, the calculated mean value is generally less representative of the true population mean (i.e., the mean becomes more strongly influenced by the nondetect replacement values). Subsurface-soil data for background and waste populations were compared using analysis of variance (ANOVA) testing (Wilcoxon Rank Sum). Electronic data were not available to conduct ANOVA testing for pondcrete and sludge samples. Results of the ANOVA testing, as well as a discussion of their meaning, are given in the following sections.

2.1 Subsurface Soil

Data for subsurface soils were available for borehole locations in the 903 Pad and Lip Area, OU2 Mound Area, OU2 Trench T-1, OU2 Trench T-3, OU2 Trench T-4, OU2 Trenches T-5 through T-11, OU9 Tanks 9 & 10, OU10 Tank 40, and OU4 (see Table 1). The largest volume of subsurface soils to be placed in the Cell are the vadose-zone soils of OU4. These subsurface soils comprise an estimated 24.1%, by volume, of all wastes destined for the Cell.

Overall detection rates were calculated for each analyte in the subsurface-soil medium. Quality parameters, such as pH, were also evaluated for these soils. In general, the subsurface soils exhibit a neutral to alkaline condition; pH ranges from 6.23 to 11.0, with a mean value of 8.1. Most metals and radionuclides are less leachable under neutral to alkaline conditions than under a lower pH (i.e., more acidic), so a mean pH of 8.1 is favorable for decreasing the mobility of most constituents of concern. However, the mobility of anionic species, such as nitrate, is not greatly dependent on pH. To put the inorganic composition of the waste soils in context, data for soils destined for the Cell were compared with data for background subsurface soils. Background data were obtained on diskette from the *Background Geochemical Characterization Report* (DOE, 1993); only data for the upper hydrostratigraphic unit (UHSU) were used. Summary statistics and detection rates for inorganic analytes in both groups (i.e., waste and background) are shown in Tables 3a and 3b. However, the numbers shown here for the waste soils do not include the data for OU4 pondcrete and sludges, which are estimated to comprise 21.7 percent (by volume) of all waste destined for the Cell. Pondcrete and sludges are addressed separately in Sections 2.4 and 2.5 of this report.

The comparison of waste soils and background soils provides a sort of "reality check" for the general nature of the waste. As shown in the right-hand column of Table 4, the results of nonparametric

ANOVA (Wilcoxon Rank Sum) indicate whether or not the two groups (i.e., waste soils and background soils) show statistically significant differences in composition. Taken at the 95-percent confidence level, a p-value of <0.05 indicates a significant difference. Of course, the results of any statistical analysis must be subjected to the scrutiny of professional judgment. A good point in case is the insignificant p-value obtained for tritium. Clearly, some of the waste soils contain substantially higher levels of tritium than do the background soils; however, the huge variance in tritium activities seen for waste soils produces huge uncertainties (i.e., the assumption of equal variances is violated), and, consequently poor power of discernment for the statistical tests. In such cases, an alternative statistical test, such as the quantile test, would have more power than the Wilcoxon test to detect differences between the two populations.

Concentrations of nitrate/nitrite in waste materials are obviously higher than those in background soils, but a significant p-value is not seen, due to the statistical violations discussed in the previous paragraph. The large variances seen for nitrate/nitrite concentrations and tritium activities invalidate the negative ANOVA results for these analytes. The mean and standard deviation for these two analytes, clearly indicate that some of the waste soils contain levels of nitrate/nitrite and tritium that are well above those seen for background soils. Overall, based on results of the ANOVA testing, the waste soils contain significantly higher levels of arsenic, calcium, americium-241, cesium-137, gross alpha, plutonium-239+240, tritium, uranium-233+234, uranium-235, and uranium-238.

2.2 OU4 Vadose-Zone Water

Pore water from the vadose zone in OU4 was collected in a series of lysimeters installed as part of the Phase-1 vadose-zone monitoring in OU4. Data for OU4 pore waters were obtained from tables in the *OU4 Proposed IM/IRA EA Decision Document*, dated February 10, 1995 (EG&G, 1995a), and are compiled here as Tables 5 and 6.

As discussed in the OU4 Decision Document, analyses of pore-water samples and soil materials from the same location were used to derive an estimated, chemical-specific partition coefficient, K_d, for selected trace metals, radionuclides, and nitrate. These K_d values, along with values obtained from the literature were presented in the Treatability Reports for pondcrete and sludges (EG&G, 1995b and 1995c).

Table 3a.
Summary of Data for Subsurface Soils: Waste Boreholes

Analyte	N	% Detects	Min	Max	Mean	Std. Dev.	Units
Aluminum	354	100.0	931	39100	9940	4907	MG/KG
Antimony	333	4.8	1.6	22.4	5.2	2.5	MG/KG
Arsenic	354	92.7	0.3	30.8	5.8	4.9	MG/KG
Barium	354	86.2	16.8	4150	120	332	MG/KG
Beryllium	353	45.9	0.055	22.9	0.71	1.23	MG/KG
Cadmium	320	39.4	0.145	547	5.5	41.3	MG/KG
Calcium	354	99.7	500	232000	22900	41010	MG/KG
Cesium	247	69.2	225	116.5	19.0	27.6	MG/KG
Chromium	354	99.2	1.0	304	14.6	24.4	MG/KG
Cobalt	354	66.4	0.6	78.1	6.6	6.0	MG/KG
Copper	354	91.2	1.8	132	12.3	9.8	MG/KG
Iron	354	100.0	1010	50800	12710	7225	MG/KG
Lead	354	100.0	1.2	278	13.4	28.4	MG/KG
Lithium	243	84.0	0.115	50.8	7.5	6.8	MG/KG
Magnesium	354	94.9	231	6300	2276	979	MG/KG
Manganese	354	100.0	1.3	3140	247	391	MG/KG
Mercury	354	26.8	0.023	6.00	0.088	0.328	MG/KG
Molybdenum	239	21.3	0.415	19.0	2.0	2.5	MG/KG
Nickel	354	84.5	2.15	173	14.7	15.4	MG/KG
Potassium	354	78.5	100	12600	1325	1074	MG/KG
Selenium	354	4.5	0.08	3.4	0.34	0.34	MG/KG
Silicon	216	98.2	1.35	14000	920	1535	MG/KG
Silver	351	10.5	0.16	96.5	1.4	6.3	MG/KG
Sodium	354	57.1	0.8	5990	419	791	MG/KG
Strontium	354	85.0	6.9	220	45.4	39.5	MG/KG
Thallium	353	16.4	0.095	1.00	0.46	0.37	MG/KG
Tin	242	28.1	1.55	91.1	18.0	12.3	MG/KG
Vanadium	354	97.7	5.0	82.2	26.7	12.8	MG/KG
Zinc	354	99.7	2.0	437	41.8	42.6	MG/KG
Ammonia	148	32.4	0.155	8.6	0.56	1.15	MG/KG
Chromium IV	12	16.7	0.265	0.86	0.40	0.22	MG/KG
Cyanide	275	12.7	0.07	43	0.98	2.94	MG/KG
Nitrate/Nitrite	208	80.3	0.0	6100	119	529	MG/KG
Oil & Grease	55	23.6	0.85	508	15.3	76.2	MG/KG
Petroleum Hydrocarbon	35	97.1	2.93	394	134	114	MG/KG
Sulfide	304	9.9	1.0	200	42.6	49.9	MG/KG
TOC	154	98.7	31.2	19200	982	2083	MG/KG
pH	276	100.0	6.23	11.0	8.1	0.5	PH
Americium-241	319	81.5	-0.06	25.0	0.277	1.696	PCi/G
Cesium-134	44	100	0.005	0.15	0.078	0.036	PCi/G
Cesium-137	318	90.9	-0.8	4.7	0.11	0.39	PCi/G
Gross alpha	305	100.0	-7.9	380	26	32.4	PCi/G
Gross beta	346	100.0	2.54	56.7	22.9	7.4	PCi/G
Plutonium-238	13	100	-0.002	0.205	0.036	0.062	PCi/G
Plutonium-239+240	333	88.0	-0.11	94	1.13	7.09	PCi/G
Radium-226	152	94.7	0.23	1.9	0.67	0.26	PCi/G
Radium-228	155	100.0	0.50	3.00	1.460	0.51	PCi/G
Strontium-89+90	315	75.2	-0.50	1.10	1.76	0.24	PCi/G
Strontium-90	6	100.0	-0.21	1.08	0.39	0.55	PCi/G
Tritium	336	74.4	-570	62000	1537	5764	PCi/G
Uranium-233+234	342	100.0	0.045	192	1.75	10.51	PCi/G
Uranium-235	237	90.7	-0.005	11.5	0.118	0.749	PCi/G
Uranium-238	352	100.0	0.23	113	1.44	6.21	PCi/G

Summary statistics calculated for RFEDS data compiled for this assessment, assuming a normal distribution.

Table 3b.
Summary of Data for Subsurface Soils: Background Boreholes

Analyte	N	% Detects	Min	Max	Mean	Std. Dev.	Units
Aluminum	98	99.0	279	102000	12710	11330	MG/KG
Antimony	66	15.2	0.95	23.5	4.5	3.7	MG/KG
Arsenic	99	70.7	0.27	41.8	3.6	4.4	MG/KG
Barium	99	88.9	12.9	777	96.1	96.6	MG/KG
Beryllium	99	81.8	0.45	23.5	4.7	4.8	MG/KG
Cadmium	81	7.4	0.08	1.5	0.6	0.3	MG/KG
Calcium	99	99.0	580	157000	7053	16180	MG/KG
Cesium	95	1.1	81.8	1415	130.0	135	MG/KG
Chromium	99	84.8	2.1	176	18.8	24.7	MG/KG
Cobalt	99	22.2	1.9	51.4	6.4	7.1	MG/KG
Copper	99	95.0	2.2	123	12.6	12.8	MG/KG
Iron	99	100.0	1300	132000	14530	13260	MG/KG
Lead	99	99.0	2	39.8	10.8	7.1	MG/KG
Lithium	99	61.6	1.4	83.2	10	8.5	MG/KG
Magnesium	99	96.0	356	32500	2853	3246	MG/KG
Manganese	99	100.0	37	3330	218	342	MG/KG
Mercury	86	25.6	0.025	2.95	0.19	0.34	MG/KG
Molybdenum	99	50.5	1	67.6	10.9	8.6	MG/KG
Nickel	96	85.4	4.3	193	19.8	20.6	MG/KG
Potassium	98	52.0	186	18700	1404	2064	MG/KG
Selenium	82	2.4	0.11	6.8	0.9	1.2	MG/KG
Silver	83	39.8	0.3	40.9	5.6	9.5	MG/KG
Silicon	*	*	*	*	*	*	
Sodium	99	17.2	63	3680	304	422	MG/KG
Strontium	99	36.4	10.2	242	52	48.3	MG/KG
Thallium	75	4.0	0.1	2.45	0.5	0.5	MG/KG
Tin	92	27.2	10.1	441	62.5	112	MG/KG
Vanadium	99	98.0	4.2	283	31.5	28.5	MG/KG
Zinc	98	92.9	0.5	486	36.3	51.4	MG/KG
Ammonia	*	*	*	*	*	*	MG/KG
Chromium IV	*	*	*	*	*	*	MG/KG
Cyanide	*	*	*	*	*	*	MG/KG
Nitrate/Nitrite	98	39.8	0.5	7.1	1.3	1.1	MG/KG
Oil & Grease	*	*	*	*	*	*	MG/KG
Petroleum Hydrocarbon	*	*	*	*	*	*	MG/KG
Sulfide	89	16.8	1.0	43000	485	4558	MG/KG
TOC	*	*	*	*	*	*	MG/KG
pH	97	100.0	6.1	9.1	8.0	0.7	PH
Americium-241	28	"100"	-0.015	0.01	-0.002	0.007	PCi/G
Cesium-134	*	*	*	*	*	*	PCi/G
Cesium-137	99	"100"	0	0.2	0.012	0.041	PCi/G
Gross alpha	99	"100"	5	48	24.9	9.3	PCi/G
Gross beta	99	"100"	6	44	24.7	6.1	PCi/G
Plutonium-238	*	*	*	*	*	*	PCi/G
Plutonium-239+240	99	"100"	-0.01	0.03	0.004	0.007	PCi/G
Radium-226	83	"100"	0.5	1.3	0.75	0.23	PCi/G
Radium-228	83	"100"	0.50	2.20	1.40	0.32	PCi/G
Strontium-89+90	99	"100"	-0.60	1.20	0.03	0.36	PCi/G
Strontium-90	*	*	*	*	*	*	PCi/G
Tritium	99	"100"	-150	440	142	127	PCi/G
Uranium-233+234	99	"100"	0.2	8.9	0.78	0.93	PCi/G
Uranium-235	99	"100"	0	0.2	0.02	0.05	PCi/G
Uranium-238	99	"100"	0.2	3.2	0.73	0.38	PCi/G

Summary statistics calculated for RFEDS data compiled for this assessment, assuming a normal distribution.
Asterisk (*) indicates that data are not available. The "100" indicates that no records were qualified as nondetects.

Table 4.
Comparison of Concentrations of Inorganic Constituents in Waste-Cell Subsurface Soils vs. Background Subsurface Soils

ANALYTE	DETECTIONS		HIGHER	MEAN CONCENTRATIONS		MEAN + 2 SD		UNITS	Wilcoxon
	Waste Cell	UHSU Bkgd	% DETECT	Waste Cell	UHSU Bkgd	Waste Cell	UHSU Bkgd		p-values
Aluminum	100.0	99.0	Cell	9940	12710	19754	35380	MG/KG	0.0155 @
Antimony	4.8	15.2	Back	*	*	*	*	MG/KG	*
Arsenic	92.7	70.7	Cell	5.8	3.6	15.6	12.4	MG/KG	0.0001 @
Barium	86.2	88.9	Back	120	96.1	784	290	MG/KG	0.4236
Beryllium	45.9	81.8	Back	0.7	4.7	3.2	14.3	MG/KG	0.0001 @
Cadium	39.4	7.4	Cell	5.5	*	88.1	*	MG/KG	*
Calcium	99.7	99.0	Cell	22900	7052	104910	39410	MG/KG	0.0001 @
Cesium	69.2	1.1	Cell	19.0	*	74.2	*	MG/KG	*
Chromium	99.2	84.8	Cell	14.6	18.8	63.6	68.2	MG/KG	0.0040 @
Cobalt	66.4	22.2	Cell	6.6	6.4	18.6	20.6	MG/KG	0.1184
Copper	91.2	95.0	Back	12.2	12.6	32.0	38.2	MG/KG	0.9263
Iron	100.0	100.0	*	12710	14530	27160	41046	MG/KG	0.0651
Lead	100.0	99.0	Cell	13.4	10.8	70.2	25.0	MG/KG	0.3489
Lithium	84.0	61.6	Cell	7.5	10.0	21.1	27.0	MG/KG	0.0010 @
Magnesium	94.9	96.0	Back	2276	2853	4234	9345	MG/KG	0.1410
Manganese	100.0	100.0	*	247	218	1028	902	MG/KG	0.6382
Mercury	26.8	25.6	Cell	0.09	0.19	0.75	0.87	MG/KG	0.0001 @
Molybdenum	21.3	50.5	Back	2.0	10.9	7.0	28.1	MG/KG	0.0001 @
Nickel	84.5	85.4	Back	14.7	19.8	45.5	61.0	MG/KG	0.0001 @
Potassium	78.5	52.0	Cell	1325	1404	3473	5532	MG/KG	0.8680
Selenium	4.5	2.4	Cell	*	*	*	*	MG/KG	*
Silicon	98.2	39.8	Cell	920	ND	3990	ND	MG/KG	NA
Silver	10.5	17.2	Back	*	*	*	*	MG/KG	*
Sodium	57.1	36.4	Cell	419	304	2000	1148	MG/KG	0.5814
Strontium	85.0	36.4	Cell	45.4	52.0	124	149	MG/KG	0.5690
Thallium	16.4	4.0	Cell	*	*	*	*	MG/KG	*
Tin	28.1	27.7	Cell	18.0	62.5	42.6	286	MG/KG	0.9318
Vanadium	97.7	98.0	Back	26.7	31.5	52.3	88.5	MG/KG	0.0533
Zinc	99.7	92.9	Cell	41.8	36.3	127	139	MG/KG	0.0713
Americium-241	81.5	"100"	NA	0.277	0.00	3.67	0.01	PCi/G	0.0001 @
Cesium-134	100	"100"	NA	0.078	ND	0.15	ND	PCi/G	NA
Cesium-137	90.9	"100"	NA	0.11	0.01	0.89	0.09	PCi/G	0.0001 @
Gross alpha	100	"100"	NA	26.0	24.9	90.8	43.5	PCi/G	0.0481 @
Gross beta	100	"100"	NA	22.9	24.7	37.7	36.8	PCi/G	0.0046 @
Plutonium-238	100	"100"	NA	0.036	ND	0.16	ND	PCi/G	NA
Plutonium-239+240	88.0	"100"	NA	1.13	0.00	15.3	0.02	PCi/G	0.0001 @
Radium-226	94.7	"100"	NA	0.67	0.74	1.19	1.21	PCi/G	0.0037 @
Radium-228	100	"100"	NA	1.46	1.40	2.47	2.04	PCi/G	0.6431
Strontium-89+90	75.2	"100"	NA	0.18	0.03	0.66	0.75	PCi/G	0.0001 @
Tritium	74.4	"100"	NA	1537	142	13065	396	PCi/L	0.1770
Uranium-233+234	100	"100"	NA	1.75	0.78	22.8	2.6	PCi/G	0.0005 @
Uranium-235	90.7	"100"	NA	0.12	0.02	1.62	0.11	PCi/G	0.0001 @
Uranium-238	100	"100"	NA	1.44	0.73	13.9	1.5	PCi/G	0.0001 @
Ammonia	32.4	ND	NA	0.56	ND	2.9	ND	MG/KG	NA
Chromium-VI	16.7	ND	NA	0.4	ND	0.83	ND	MG/KG	NA
Cyanide	12.7	ND	NA	0.98	ND	6.86	ND	MG/KG	NA
Nitrate/Nitrite	80.3	39.8	Cell	119	1.2	1177	3.4	MG/KG	0.4491
Oil and Grease	23.6	ND	NA	15.3	ND	168	ND	MG/KG	NA
Petro. Hydrocarb	97.1	ND	NA	134	ND	362	ND	MG/KG	NA
Sulfide	9.9	16.8	Back	*	*	*	*	MG/KG	*
TOC	98.7	ND	NA	982	ND	5148	ND	MG/KG	NA
pH	100	100	*	8.1	8.0	9.2	9.4	MG/KG	0.5194

NA = Not Applicable; ND = No Data; * = < 20% Detects, Mean Not Calculated; "100" means 100% detection is assumed (per DOE Order 5400.1).

Nonparametric ANOVA testing was performed using the Wilcoxon Rank Sum test; please see text for discussion and qualification of these results.

An @ indicates that the Wilcoxon test is significant (P-value < 0.05).

Table 5.
Pore-Water Data for pH and Specific Conductivity

Lysimeter Location	pH		Specific Conductivity (uS)	
	Range	Mean	Range	Mean
40293	10.8-12.6	11.7	2.06-5.01	3.54
40393	10.8-12.9	11.6	1.62-2.58	1.94
40593	7.9-9.1	8.5	1.78-1.88	1.83
40793	9.8-10.9	10.2	0.52-1.18	0.81
40993	6.8-10.3	9.0	8.14-19.9	16.18
40993	6.9-10.9	9.5	NA	19.99
41293	9.0-11.0	10.1	1.11-2.68	2.24
41593	6.2-9.0	6.8	1.24-19.9	15.04
41793	7.8-12.2	9.8	1.06-7.61	2.27
42493	NA	7.6	NA	2.04
42493	7.0-7.8	7.3	1.43-2.64	2.22
42893	7.0-7.8	7.3	0.77-2.47	1.93
43193	7.4-7.9	7.7	2.76-4.55	3.25
43193	6.5-7.3	7.0	8.55-11.22	9.72
43693	7.0-7.8	7.4	4.36-19.9	18.19
43793	7.1-9.7	8.2	1.15-2.90	2.11
43793	8.1-11.4	10.8	2.18-3.84	3.02
44093	6.9-9.6	8.0	0.51-1.29	0.90
44093	8.0-8.5	8.2	2.57-3.20	2.91
44393	7.3-9.8	8.5	0.50-1.35	1.03
44393	9.9-11.5	10.4	0.86-2.50	1.09

Summary data from OU4 IM/IRA EA Decision Document; Draft February 10, 1995.

NA = Not applicable.

Table 6.
Summary of Pore-Water Data for OU4 Lysimeters

Analyte	N	% Detects	Min	Max	Mean	Units
Aluminum	67	37.3	25	10700	984	UG/L
Antimony	66	56.1	0	ND	ND	UG/L
Arsenic	66	90.1	0	120	8.4	UG/L
Barium	67	86.6	0	1470	122	UG/L
Beryllium	66	56.1	0	ND	ND	UG/L
Cadmium	68	14.7	3	54	14	UG/L
Calcium	66	95.4	0	3490000	110200	UG/L
Cesium	27	11.1	39	75	59	UG/L
Chromium	66	60.1	0	10200	255	UG/L
Cobalt	67	58.2	0	2100	60.2	UG/L
Copper	68	14.7	6	900	107	UG/L
Iron	69	63.8	28	37400	1800	UG/L
Lead	70	47.1	1	1110	48.2	UG/L
Lithium	27	66.7	24	6170	984	UG/L
Magnesium	65	87.7	0	236000	20120	UG/L
Manganese	69	73.9	1	13100	925	UG/L
Mercury	70	0.0	ND	ND	ND	UG/L
Molybdenum	26	53.8	26	3660	547	UG/L
Nickel	66	68.2	0	6460	160	UG/L
Potassium	67	91.0	0	11400000	308700	UG/L
Selenium	66	74.2	0	19	1.4	UG/L
Silicon	26	96.2	11300	288000	71320	UG/L
Silver	69	24.6	4	21	10.3	UG/L
Sodium	66	98.5	0	24000000	905400	UG/L
Strontium	26	96.2	190	20100	2613	UG/L
Thallium	67	56.7	0	89	2.3	UG/L
Tin	27	0.0	ND	ND	ND	UG/L
Vanadium	66	71.2	0	730	24.8	UG/L
Zinc	69	75.4	6	1270	104	UG/L
Nitrate/Nitrite	77	97.4	4	17600000	1064020	UG/L
Sulfide	13	46.2	1	43000	17900	UG/L
Cyanide	18	11.1	0	1000	500	UG/L
Americium-241	1	0.0	ND	ND	ND	PCi/L
Gross alpha	15	66.7	4	6300	706	PCi/L
Gross beta	15	100.0	4	5400	433	PCi/L
Plutonium-239+240	1	100.0	0	0.013	0.013	PCi/L
Radium-226	9	100.0	0	6	1.804	PCi/L
Radium-228	2	100.0	3	5	4.150	PCi/L
Strontium-89+90	1	100.0	1	1	0.60	PCi/L
Total Radiocesium	1	0.0	ND	ND	ND	PCi/L
Tritium	14	35.7	620	5600	2384	PCi/L
Uranium-233+234	14	100.0	1	3400	274	PCi/L
Uranium-235	14	85.7	0	120	11.48	PCi/L
Uranium-238	15	100.0	0	3700	264.5	PCi/L

Summary data from OU4 IM/IRA EA Decision Document, Draft February 10, 1995. ND = not defined.

The formula used to calculate K_d values from lysimeter data was as follows:

$$K_d = \frac{\text{Concentration in solid phase (i.e., subsurface soil)}}{\text{Concentration in the liquid phase (i.e., pore water)}}$$

These derived K_d values were then refined through model calibration (EG&G, 1995b). In addition, the K_d values from literature sources were also reviewed for comparison to these calculated K_d values (see Tables 7a and 7b).

In addition to using K_d values to determine what concentration in soils will lead to exceedances of groundwater standards, the geochemical modeling of vadose-zone water (i.e., pore water) would be helpful in providing a picture of rock/water interaction under varying Eh-pH conditions. Unfortunately, analyses of major anions (e.g., bicarbonate, chloride, sulfate, etc.) are not reported in the Decision Document, so geochemical modeling cannot be performed separately for vadose-zone waters.

2.3 OU4 Pondcrete

Treatability studies, conducted in support of pondcrete disposal at RFETS, evaluated the leachability of pondcrete. Pondcrete samples were subjected to the toxicity characteristic leaching procedure (TCLP), and the subsequent leachate analyzed for organic and inorganic constituents. These treatability studies evaluated both treated and untreated pondcrete, and both the "triwall" pondcrete and the "metals" pondcrete, which are so-called based on the type of storage container (EG&G, 1995b). Treatment of pondcrete involved the addition of lime, concrete, and fly ash to stabilize the pondcrete material.

Waste acceptance criteria (WAC) were used to determine whether or not leachate derived from treated and untreated pondcrete would meet disposal standards. The liquid-phase WAC is defined as "...the chemical-specific leachate concentration generated from the waste material in an engineered disposal facility which will ensure an acceptable groundwater concentration at the point of compliance (POC) within a required protective time frame" (EG&G, 1995b). The WAC for selected metals and radionuclides for the 1-inch-per-year infiltration rate (assumed as typical for RFETS) were given in tables in the Pondcrete Treatability Report (EG&G, 1995b), and are as follows:

Radionuclides	Waste Criteria	Metals & Nitrate	Waste Criteria
Americium-241	74.5 pCi/L	Arsenic	142 μg/L
Cesium-134	12,800 pCi/L	Beryllium	14.2 μg/L
Cesium-137	737 pCi/L	Cadmium	51.8 μg/L
Plutonium-239+240	4.43 pCi/L	Chromium	881 μg/L
Radium-226	415 pCi/L	Sodium	14,900 μg/L
Uranium-233+234	254 pCi/L	Nitrate	166,000 μg/L
Uranium-235	10.2 pCi/L		
Uranium-238	177 pCi/L		

Table 7a.
Kd Values (L/kg) for Selected Analytes

Analyte	Calibr'd Kd Vadose Zone	Calibr'd Kd Sat'd Zone	Literature Kd Value	Literature Kd Value	Kd Calculated from Lysimeter	RFETS Vadose	RFETS Sat'd Zone
Americium-241	100	10	8.2 - 300000	700	NA	100	10
Arsenic	2	0.5	•	200	NA	*	•
Beryllium	5	1	250	650	NA	*	*
Cadmium	5	1	2.7 - 625	6.5	597	*	•
Cesium-134	1	0.1	40 - 3968	1000	NA	*	*
Cesium-137	1	0.1	40 - 3968	1000	NA	1	0.1
Chromium	35	1.5	1.7 - 1729	850	NA	•	•
Nitrate	0.01	0.01	•	•	0.127	•	*
Plutonium-239+240	100	20	27 - 36000	4500	NA	100	20
Radium-226	690	106	57 - 21000	450	690	690	106
Sodium	10	1.5	*	100	NA	*	*
Uranium-233+234	17	2	.03 - 2200	450	19.8	17	2
Uranium-235	17	2	.03 - 2200	450	NA	17	2
Uranium-238	17	2	.03 - 2200	450	14.5	17	2

Tables from "Treatability Study Report and Process Formulation Report for Pondcrete," June 1995.
Asterisk (*) indicates data not available in the specific reference. NA = not applicable or not available.

Table 7b.
Kd Values (L/kg) Used at Other DOE Facilities for Selected Radionuclides

Analyte	Oak Ridge	Savannah River	Hanford	INEL Sat'd Zone	INEL Vadose	Fernald Sat'd Zone	Fernald Vadose
Americium-241	40	150	100	NA	NA	10	100
Cesium-137	3000	100	1	20	20	1370	1810
Plutonium-239+240	40	100	100	200	2000	100	1700
Radium-226	3000	500	10	5	50	106	696
Uranium-233+234	40	50	0	100	1000	1.78	3.1
Uranium-235	40	50	0	100	1000	1.78	3.1
Uranium-238	40	50	0	100	1000	1.78	3.1

Tables from "Treatability Study Report and Process Formulation Report for Pondcrete," June 1995.
Asterisk (*) indicates data not available in the specific reference. NA = not applicable or not available.

Results of the leachate analyses showed a strong dependence between pH and constituent concentrations in the leachate. In general, a moderately alkaline condition (pH = 9 to 11) significantly reduced the concentrations of dissolved trace metals and radionuclides in the leachate (see Figure 1). Nitrate and sodium concentrations were unaffected by variations in pH.

Based on the results of the treatability study, it was determined that pondcrete subjected to "...the treatment process will meet all applicable waste-acceptance criteria..." given stated assumptions (EG&G, 1995b). Only sodium in the treated pondcrete was seen to exceed the waste acceptance criteria (WAC). In contrast, untreated pondcrete leached excessive amounts (i.e., > WAC) of plutonium-239+240, americium-241, uranium-238, beryllium, and cadmium, under a 1-inch-per-year infiltration rate, which is the current best estimate for the infiltration rate at RFETS. Assuming that pondcrete materials are treated prior to placement in the Cell, the possible composition of leachate derived from the stored pondcrete should meet WAC for the scenario of 1-inch-per-year infiltration rate. The mean leachate compositions for pondcrete samples are summarized in Table 8.

The mean concentrations/activities of leachate analytes for **"triwall" pondcrete** are for those samples treated with lime, fly ash, and cement. The mean values for leachate analytes for **"metals" pondcrete** are for those samples treated with lime, fly ash, and cement. For additional details, the reader should refer to the Pondcrete Treatability Report (EG&G, 1995b).

2.4 OU4 Sludges

Sludge samples from the Solar Evaporation Ponds and from the Building 788 clarifier were subjected to TCLP testing, and the subsequent leachate analyzed for organic and inorganic constituents. The leachate was analyzed for selected hazardous constituents, which included arsenic, barium, cadmium, chromium, lead, nickel, sodium, nitrate, and selected radionuclides. These treatability studies evaluated both treated and untreated sludges. Treatment of the sludges involved the addition of lime, concrete, and fly ash to stabilize the sludge materials. Leachability of constituents of concern was determined for both the treated and untreated materials.

As with the pondcrete, results of the leachate analyses for sludges showed a strong dependence between pH and constituent concentrations in the leachate. In general, a moderately alkaline condition (pH = 9 to 11) significantly reduced the concentrations of trace metals and radionuclides in the leachate (see Figure 1).

Based on the results of the treatability study, it was determined that treated sludges will meet all WAC, given the stated assumptions (EG&G, 1995c). Only sodium in the treated sludges was seen to exceed the WAC. In contrast, untreated sludge materials leached excessive amounts (i.e., > WAC) of plutonium-239+240, uranium isotopes, arsenic, beryllium, cadmium, nitrate, and sodium under a scenario of a 1-inch-per-year infiltration rate. Values of WAC are shown in Section 2.3 above. The mean leachate compositions for various sludge materials are listed below and summarized in Table 8.

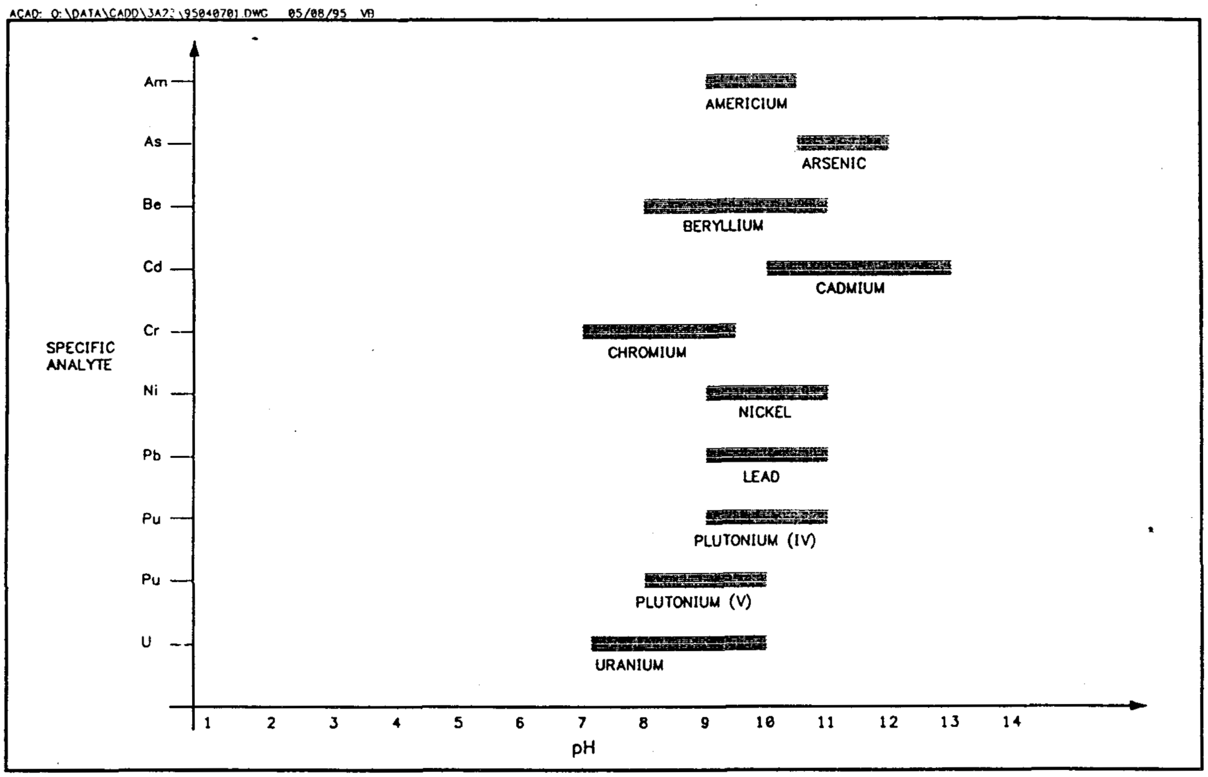

Figure 1. Optimum pH Values for Precipitation of Various Metal Hydroxides. (Figure from *Pondcrete Treatability Study Report and Process Formulation Report*, Revision 0, June 1995).

Table 8.
Average Leachate (TCLP) Compositions for Treated Pondcrete and Sludges

Analyte	Phase II "Triwall" Pondcrete	Phase I "Metals" Pondcrete	Phase II Pond 207A/B Sludges	Phase II Pond 207C Sludges	Phase II Clarifier Sludges	Phase II Pond 207C & Clarifier Sludges	Units
Americium-241	<0.35	<0.15	<0.24	1	<0.33	<0.3	PCi/L
Cesium-134	<5.5	*	<5.3	<5.5	<5	<5.7	PCi/L
Cesium-137	<5.7	•	<5.8	<6.5	<5.3	<6	PCi/L
Plutonium-238	<0.11	<0.05	<0.095	<0.05	<0.095	<0.1	PCi/L
Plutonium239+240	<0.07	0.034	<0.05	<0.05	<0.054	<0.1	PCi/L
Radium-226	1.4	0.75	0.28	0.52	0.63	0.54	PCi/L
Uranium-233+234	0.044	<0.4	0.06	0.15	0.05	0.08	PCi/L
Uranium-235	<0.038	<0.36	0.08	<0.064	<0.05	<0.07	PCi/L
Uranium-238	0.042	<0.45	0.06	0.16	<0.06	0.08	PCi/L
Arsenic	<100	<100	<100	550	<100	140	UG/L
Beryllium	<0.5	<0.5	<0.5	<3.0	<0.55	<0.8	UG/L
Cadmium	<5.0	<5.0	<5.0	<5.0	5	<5	UG/L
Chromium	198	150	125	150	160	170	UG/L
Lead	<50	<50	<50	<50	<50	<50	UG/L
Nickel	<20	<20	<20	27	<20	<20	UG/L
Sodium	413000	555000	208000	3070000	383000	2397000	UG/L
Nitrate/Nitrite	110700	125000	12900	1320000	84300	1417000	UG/L
pH	11.4	11.1	11.3	11.8	11.1	11.8	PH
Reference	Table 3-11 EG&G, 1995b	Table 3-19 EG&G, 1995b	Table 3-14 EG&G, 1995c	Table 3-27 EG&G, 1995c	Table 3-37 EG&G, 1995c	Table 3-39 EG&G, 1995c	

NOTE: If reported detection rate was > 50%, then a replacement value of one-half the detection limit was used for calculation of summary statistics.

Assuming that the sludges are treated prior to placement in the Cell, the possible composition of leachate derived from the stored sludges should meet WAC for the scenario of a 1-inch-per-year infiltration rate. The mean concentrations/activities reported for leachate analytes for **Ponds 207 A and B sludges, Pond 207 C sludges,** and **clarifier sludges** are for those samples treated with lime, fly ash, and cement (Phase II). For additional details, the reader should refer to the Pondcrete Treatability Report (EG&G, 1995c).

2.5 Groundwater

An evaluation of the groundwater chemistry in areas of contaminated subsurface soils destined for the Cell may also provide insights as to the likely composition of waste leachates. Locations for which both subsurface-soil and groundwater data were available are listed in Table 2. Summary statistics were calculated for these groundwater data (Table 9), and a series of modeling runs were conducted using mean concentrations and varying Eh conditions. Discussion of geochemical modeling and the results of modeling are given below in Section 3.0.

3.0 GEOCHEMICAL MODELING

Geochemical modeling takes into account solution chemistry, temperature, pH, and Eh to determine speciation and solubilities of various components. These four variables are the main factors influencing the solubility and behavior of inorganic constituents. Geochemical modeling is based on thermodynamic data and does not take into account various kinetic factors that may influence water/rock interactions; professional judgment should always be applied when evaluating model output.

Model input includes concentration data, pH, Eh, temperature, and specification of either the Debye-Huckel or Davies equation for determining individual ion-activity coefficients. By using actual concentration data, but varying selected parameters such as Eh, the general effects of such changes on constituent behavior can be assessed. This allows the user to evaluate and define optimum conditions for a given situation.

Using WATEQF (Plummer *et al.*, 1976), a limited modeling analysis was performed for groundwater related to the wastes destined for the proposed waste cell (see Table 9), in addition to modeling of an estimated leachate solution (see Table 10). Groundwater models were run for three Eh conditions (-0.2, 0.0, and 0.5 volts), whereas the estimated leachate solution was run for only two Eh conditions (0.0 and 0.5 volts).

Model output includes a listing of the distribution of aqueous species for each constituent, as well as the calculated saturation indices (SI) for a variety of phases. The SI is defined as the log of the ratio of the ion-activity product (IAP) to the solubility product (K_{sp}) for a given phase. The SI value for each phase indicates the likelihood that the phase will precipitate from, or dissolve into, the groundwater. If the SI value is approximately zero (i.e., +/- 0.5), then the phase is in equilibrium with the solution; if the SI value is less than zero (i.e., < 0.5), then the phase is likely to dissolve; if the SI value is greater than zero (i.e., > 0.5), then the phase is likely to precipitate. Modeling results are discussed below.

Table 9.
Summary of Groundwater Data for Areas with Contaminated Subsurface Soils

Analyte (dissolved)	N	% Detects	Min	Max	Mean	Std. Dev.	Units
Aluminum	97	12.4	5.5	269	22.1	34.9	UG/L
Antimony	103	3.9	5.5	51.5	13.1	7.1	UG/L
Arsenic	102	14.7	0.35	9	1.5	1.8	UG/L
Barium	105	99.1	43.3	675	195	114	UG/L
Beryllium	104	2.9	0.11	1.5	0.51	0.19	UG/L
Cadmium	104	4.8	0.9	21.7	1.6	2.1	UG/L
Calcium	100	100.0	33500	678000	160450	147770	UG/L
Cesium	84	1.2	6.5	309	70.1	101	UG/L
Chromium	105	1.0	1	4.8	1.8	0.6	UG/L
Cobalt	105	14.3	1	6.9	2.7	1.4	UG/L
Copper	104	22.1	1	17.6	2.2	1.9	UG/L
Iron	97	20.6	2	342	18.6	43.6	UG/L
Lead	103	5.8	0.35	13.8	0.8	1.3	UG/L
Lithium	100	55.0	1	42.4	12.3	9.5	UG/L
Magnesium	100	100.0	4120	105000	20060	23790	UG/L
Manganese	100	69.0	0.5	1850	228	420	UG/L
Mercury	105	1.0	0.05	0.23	0.099	0.017	UG/L
Molybdenum	96	10.4	1.5	34.1	6.7	5.5	UG/L
Nickel	103	17.5	1.5	86.1	9.3	14.6	UG/L
Potassium	100	91.0	242	11100	3098	2312	UG/L
Selenium	105	19.1	0.5	12	1.4	1.4	UG/L
Silicon	32	100.0	3630	9780	6632	1393	UG/L
Silver	105	1.0	1	25.1	1.8	2.4	UG/L
Sodium	100	100.0	4840	497000	46630	92500	UG/L
Strontium	100	100.0	240	3110	749	749	UG/L
Thallium	105	1.9	0.45	18.9	1.5	2.2	UG/L
Tin	100	17.0	3.6	74.6	14.2	12.5	UG/L
Vanadium	105	19.1	1	93	4.7	9.8	UG/L
Zinc	99	28.3	0.6	65.3	6.1	8.9	UG/L
Bicarb as CaCO3	127	100.0	65000	690000	264800	79440	UG/L
Chloride	130	97.7	500	3010000	170040	439190	UG/L
Fluoride	130	99.2	100	1410	505	240	UG/L
Nitrate/Nitrite	128	94.5	10	444000	9400	39400	UG/L
Orthophosphate	91	45.1	1.9	247	23	44	UG/L
Silica	64	100.0	8000	20965	15830	2894	UG/L
Sulfate	132	96.2	10000	250000	40744	36240	UG/L
TDS	127	100.0	210000	3800000	672095	775800	UG/L
TSS	127	96.1	2000	43000000	1553800	5121800	UG/L
pH	10	100.0	6.8	10.5	7.9	1.0	PH
Americium-241	6	83.3	0.006	0.435	0.108	0.169	PCi/L
Cesium-134	6	100.0	-0.63	0.71	-0.2	0.48	PCi/L
Cesium-137	8	87.5	-0.37	0.37	0.07	0.24	PCi/L
Gross alpha	99	88.9	0.32	67.1	10.4	11	PCi/L
Gross beta	95	90.5	-1.4	56.4	9.5	10.3	PCi/L
Plutonium-239+240	8	87.5	-0.001	1.999	0.403	0.01	PCi/L
Radium-226	45	95.6	0	2.82	0.87	0.67	PCi/L
Tritium (total)	110	53.6	-109	1067	154	163	PCi/L
Uranium-233+234	95	100.0	0.32	24.4	5.63	5.49	PCi/L
Uranium-235	95	76.8	-0.085	1.5	0.27	0.34	PCi/L
Uranium-238	95	100.0	0.24	75.7	7.68	12.01	PCi/L

Summary statistics calculated for RFEDS data compiled for this evaluation. ND = no data.
Locations for which data were evaluated are given in Table 2 of this report.

Table 10.
Summary of Data and Estimated Leachate Composition for Waste-Cell Wastes

Analyte	52.5% OU4 Pore Water - 52.5%		25.8% Waste-site GW		14.5% OU4 Pondcrete		7.2% OU4 Sludges		Estimated Leachate Composition	Units
	BKGD	Mean	BKGD	Mean	BKGD	Mean	BKGD	Mean		
Aluminum		984		22.1	X	114	X	114	547	UG/L
Antimony	X	25		13.1	X	25	X	25	22	UG/L
Arsenic		8.4		1.5	X	27		550	48	UG/L
Barium		122		195	X	84	X	84	133	UG/L
Beryllium	X	2.2		0.51	X	2.2	X	2.2	1.8	UG/L
Cadmium		14		1.6	X	2.4		5	8.5	UG/L
Calcium		110200		160450	X	55205	X	55205	111230	UG/L
Cesium		59		70.1	X	446	X	446	146	UG/L
Chromium		255		1.8		180		170	173	UG/L
Cobalt		60.2		2.7	X	20.5	X	20.5	37	UG/L
Copper		107		2.2	X	10.8	X	10.8	59	UG/L
Iron		1800		18.6	X	94	X	94	970	UG/L
Lead		48.2		0.8	X	8.6	X	8.6	27	UG/L
Lithium		984		12.3	X	38.7	X	38.7	528	UG/L
Magnesium		20120		20060	X	10026	X	10026	17910	UG/L
Manganese		925		228	X	32.7	X	32.7	550	UG/L
Mercury	X	0.59		0.099	X	0.59	X	0.59	0.46	UG/L
Molybdenum		547		6.7	X	61.2	X	61.2	302	UG/L
Nickel		160		9.3	X	15.5		15.5	90	UG/L
Potassium		308700		3098	X	11270	X	11270	165300	UG/L
Selenium		1.4		1.4	X	20.5	X	20.5	5.5	UG/L
Silicon		71320		6632	X	62.8	X	62.8	39170	UG/L
Silver		10.3		1.8	X	31900	X	31900	62.8	UG/L
Sodium		905400		46630		555000		3000000	783800	UG/L
Strontium		2613		749	X	352	X	352	1640	UG/L
Thallium		2.3		1.5	X	29.6	X	29.6	8	UG/L
Tin	X	108		14.2	X	108	X	108	84	UG/L
Vanadium		24.8		4.7	X	12.4	X	12.4	17	UG/L
Zinc		104		6.1	X	14.3	X	14.3	60	UG/L
Bicarb as CaCO3	X	223810		264800	X	223810	X	223810	234400	UG/L
Chloride	X	12832		170040	X	12832	X	12832	53400	UG/L
Fluoride	X	690		505	X	690	X	690	640	UG/L
Nitrate/Nitrite		1064020		9400		125000		1000000	651200	UG/L
Orthophosphate	X	13		23	X	13	X	13	16	UG/L
Silica	X	14300		15830	X	14300	X	14300	14700	UG/L
Sulfate	X	86230		40744	X	86230	X	86230	74500	UG/L
TDS	X	354151		672095	X	354151	X	354151	736200	UG/L
pH		8.8		7.9		11.2		11.5	9.1	UG/L
Americium-241	X	0.011		0.108	X	0.011		1	0.11	PCi/L
Cesium-134	X		X		X		X		ID	PCi/L
Cesium-137	X	0.42		0.07	X	0.42	X	0.42	0.33	PCi/L
Gross alpha		706		10.4	X	8.4	X	8.4	375	PCi/L
Gross beta		433		9.5	X	4.9	X	4.9	230	PCi/L
Plutonium-239+240		0.013		0.403		0.034	X	0.011	0.12	PCi/L
Radium-226		1.804		0.87		1.4		0.5	1.4	PCi/L
Radium-228		4.15	X	2.12	X	2.12	X	2.12	3.2	PCi/L
Tritium (total)		2384		154	X	102	X	102	1310	PCi/L
Uranium-233+234		274		5.63	X	6.91	X	6.91	147	PCi/L
Uranium-235		11.48		0.27	X	0.195	X	0.195	6.1	PCi/L
Uranium-238		264.5		7.68	X	4.83	X	4.83	142	PCi/L

X indicates that the background value was used for that analyte; ID indicates insufficient data provided in reference source.

3.1 Modeling of Groundwater Chemistry

Using the mean concentrations of constituents, models were run for three redox conditions: Eh = -0.2 volts (reducing), Eh = 0.2 volts (mildly oxidizing), and Eh = 0.5 volts (oxidizing). The dominant aqueous species, as well as phases that may control solubility, were then reviewed for each of the three redox conditions (see Figure 2).

At the low Eh value of -0.2 volts, representative of environments isolated from the atmosphere, the solution is oversaturated with respect to Ag_2Se; native silver; copper sulfide - Cu_2S; chromite - $FeCr_2O_4$; PbSe; ferroselite - $FeSe_2$; illite, smectite, and kaolinite clays; ZnSe; native selenium; FeSe; and uranium species - U_4O_9, uraninite (UO_2), and coffinite ($USiO_4$); in addition to various iron oxides, calcite, and quartz.

Unconfined groundwater in the shallow subsurface probably exhibits Eh values in the range of 0.0 to 0.2 volts. At an Eh of 0.2 volts, the solubility of uranium species increases markedly. The solution is still oversaturated with respect to iron oxides and oxyhydroxides, clays, calcite, native silver and silver selenide, and quartz. Molybdenum, vanadium, selenium, arsenic, and uranium have oxyanion complexes or negatively charged carbonate complexes as the dominant aqueous species.

To represent an environment in contact with the atmosphere (e.g., surface water or leachates from wastes stored aboveground), an Eh = 0.5 volts was used. Again, iron, aluminum, and manganese oxides and oxyhydroxides are predicted to precipitate, along with calcite and quartz, and various clay minerals. Actually, the solution appears to be at or near equilibrium with calcite, quartz, barite, pyrolusite, manganese phosphate, and hydroxyapatite. The groundwater remains undersaturated with respect to uranium-bearing phases, such as uranium carbonates. Anionic complexes for molybdenum, uranium, vanadium, chromium, arsenic, and selenium are the dominant species for these constituents in solution.

3.2 Modeling of Estimated Leachate Solution

An estimated leachate composition was derived by assembling data for vadose-zone water, groundwater, and TCLP leachates from treated pondcrete and sludges. The concentration data were then weighted for the relative proportion of a waste type. As shown in Table 10, the mean concentration multiplied by the relative proportion, which is based on the estimated volume of waste, was used to generate an estimate of leachate. If data for specific analytes were unavailable, then the mean concentration for background groundwater was used for that proportion. The mean pH of 9.1, an oxidizing Eh of 0.5 volts, and a temperature of 12°C were used for one model and a more reducing Eh of 0.0 volts was used for the second model (all other parameters unchanged).

The proportions of each waste type used for the estimated leachate composition were 52.5% OU4 vadose-zone water, 25.8% waste-site groundwater, 14.5% treated-pondcrete leachate, and 7.2% treated-sludge leachate (see Table 10). The estimated values shown here should be considered rough, preliminary estimates of constituent concentrations. As noted below, changes in physicochemical conditions can change the leachate composition.

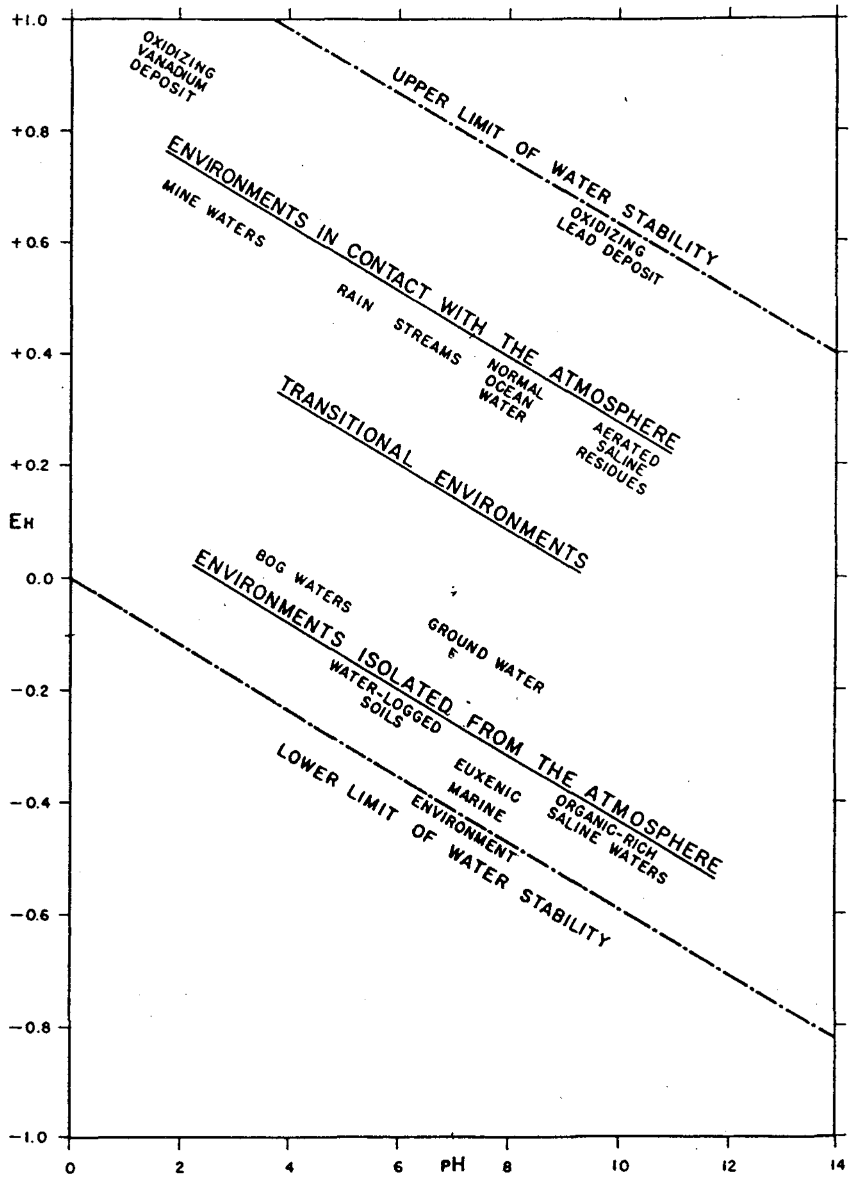

Figure 2. Generalized Eh-pH diagram showing conditions of natural environments. (From Garrels and Christ, 1965).

The hypothetical leachate solution produced model outputs with a reasonable 9.0% charge-balance error, and a distribution of aqueous species that indicates an abundance of nitrate and sodium as free ions. The dominant species in solution, in order of decreasing molality (for the Eh=0.0 case) are listed in Appendix A tables. (Molality is defined as moles of solute per 1000 grams of water; for dilute solutions at normal temperatures, molality is essentially equal to molarity. Molarity is moles of solute per 1000 grams of solution).

For the case the model run with an oxidizing Eh of 0.5 volts, the speciation indicates the importance of uranium-carbonate complexes. In the presence of carbonate, the solubility of uranium is greatly increased (compare Figures 3a and 3b), and the amount of dissolved uranium is much higher than it would be in carbonate-free water (Drever, 1988). In addition, oxyanions of chromium, molybdenum, arsenic, vanadium, and selenium are predicted to be the dominant aqueous species for these constituents. These species are important from a migration perspective because anions are generally more mobile than cations. The mobility of anions is related to the presence of abundant cation-exchange sites on clays and iron oxides, but fewer anion-exchange sites in the substrate. Thus, anionic species such as nitrate, chloride, sulfate, and oxyanions of metals, are generally less retarded as the solution migrates in the subsurface.

Output from the model run with an Eh of 0.0 volts also shows the importance of oxyanion complexes for molybdenum, chromium, selenium, vanadium, and arsenic. In general, the activities of anionic complexes of chromium, selenium are higher in the case of Eh = 0.0 volts, whereas the activities of major-ion species are largely unchanged. In particular, the activities of $Cr(OH)_4^-$, Fe^{+2}, $FeOH^+$, SeO_3^{-2}, Cu^+, $CuCl_2^-$, CuCl, $HSeO_3^-$ are markedly greater under an Eh of 0.0 volts, as compared to an Eh of 0.5 volts.

4.0 SUMMARY AND CONCLUSIONS

Wastes derived from OU4 will constitute approximately 75 percent of the total waste mass in the Waste Cell, with pondcrete and sludge materials comprising 21.7% of the total waste volume, and OU4 vadose-zone soils comprising 24.1% of the total waste volume. Because OU4 contributes the bulk of waste for the Cell, this evaluation focussed on the existing data for OU4 materials. Based on these data, nitrate, sodium, gross alpha, gross beta, tritium, and uranium isotopes appear to be the most mobile constituents in the OU4 wastes.

For subsurface-soil wastes to be stored at the proposed Cell, constituent concentrations in the waste materials were statistically compared to those in background subsurface soils. This comparison highlights those constituents that may be released in concentrations higher than those of background groundwater. However, just because the solid wastes contain constituent concentrations higher than those of background soils, does not necessarily mean that waste leachates will contain proportionately higher levels of those constituents.

Based on the estimated volumes of waste destined for the Cell and the available data for leachates, pore water, and groundwater from the wastes and waste areas, a general leachate composition was calculated (see Table 10). Geochemical modeling of the leachate suggests that iron, aluminum, and manganese

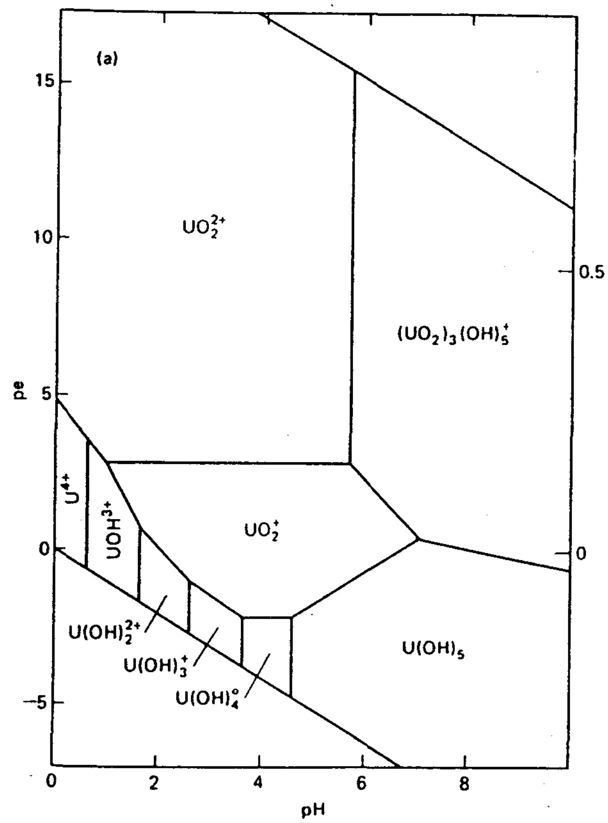

Figure 3a. Distribution of dissolved uranium species in a carbonate-free system at 25°C (Figure from Drever, 1988).

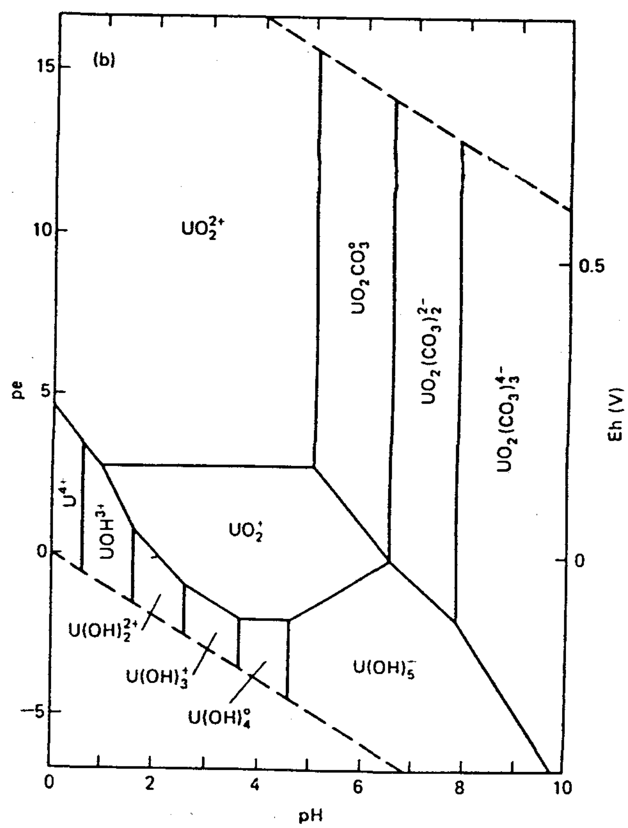

Figure 3b. Distribution of dissolved uranium species in a system containing carbonate, at 25°C. (Figure from Drever, 1988).

oxides and oxyhydroxides, along with clay minerals, calcium carbonate, and compounds containing zinc, copper, barium, chromium, strontium will precipitate from the leachate. Silver, lead, and molybdenum appear to be at approximate equilibrium with the leachate, under the specified Eh-pH conditions. On the other hand, the leachate is undersaturated with respect to uranium, vanadium, arsenic, radium, and selenium phases, so these constituents would still tend to remain in solution. As long as uranium, vanadium, arsenic, and selenium exist as oxyanions, it is unlikely that they will be strongly retarded under the given Eh-pH conditions.

The solubility and behavior of iron is strongly influenced by Eh-pH conditions. The oxidized form of iron (ferric, Fe^{+3}) is much less soluble than the reduced form (ferrous, Fe^{+2}). Ferric oxyhydroxides, generalized as $Fe(OH)_3$, form suspended particulates. The importance of these ferric oxyhydroxide particulate is that their surfaces have a large capacity for the adsorption of trace metals (Hem, 1992). If Eh decreases and the iron is reduced, the adsorbed trace metals, in addition to the iron, will be released into solution. Where the solubility of trace elements is controlled by adsorption onto oxide surfaces, the dissolved concentrations of these elements will be highly sensitive to changes in Eh and pH. At RFETS, much of the plutonium and americium in near-surface waters may be adsorbed onto iron oxyhydroxide particulates, so Eh conditions may have significant impact on both trace metal and radionuclide mobility.

In general, most metals, including plutonium and americium, are less mobile in a neutral, oxidizing environment; however, those metals and radionuclides that tend to form oxyanions or other negatively charged aqueous species tend to remain mobile. Additionally, anions such as nitrate, chloride, and sulfate tend to be mobile under most naturally occurring Eh-pH conditions. Controlling the migration of anionic species probably presents the greatest challenge for wastes contaminated with numerous metals and radionuclides. Uranium tends to be immobilized under reducing conditions, but plutonium and americium are mobilized under these conditions. By modeling the leachate for a range of Eh-pH conditions, the optimum conditions for immobilization can be defined.

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Appendix A
Aqueous Speciation of constituents in Estimated Waste-Cell Leachate

Eh = 0.0 Volts			Eh = 0.5 Volts		
SPECIES	PPM	MOLALITY	SPECIES	PPM	MOLALITY
NO3 -	2.88270E+03	4.66967E-02	NO3 -	2.88270E+03	4.66967E-02
NA +	7.80660E+02	3.41067E-02	NA +	7.80660E+02	3.41067E-02
K +	1.65027E+02	4.23906E-03	K +	1.65027E+02	4.23906E-03
HCO3 -	2.16955E+02	3.57133E-03	HCO3 -	2.16955E+02	3.57133E-03
CA 2+	1.00756E+02	2.52497E-03	CA 2+	1.00756E+02	2.52497E-03
CL -	5.33527E+01	1.51153E-03	CL -	5.33535E+01	1.51155E-03
MG 2+	1.64351E+01	6.78994E-04	MG 2+	1.64352E+01	6.78995E-04
SO4 2-	6.16884E+01	6.45010E-04	SO4 2-	6.16901E+01	6.45028E-04
CO3 2-	1.62828E+01	2.72536E-04	CO3 2-	1.62831E+01	2.72540E-04
H4SIO4	2.15717E+01	2.25426E-04	H4SIO4	2.15717E+01	2.25426E-04
CACO3	1.68300E+01	1.68893E-04	CACO3	1.68295E+01	1.68888E-04
LI +	5.27316E-01	7.63285E-05	LI +	5.27316E-01	7.63285E-05
CASO4	8.54916E+00	6.30733E-05	CASO4	8.54901E+00	6.30722E-05
NASO4 -	5.78539E+00	4.88102E-05	NASO4 -	5.78541E+00	4.88104E-05
NAHCO3	3.85061E+00	4.60479E-05	NAHCO3	3.85056E+00	4.60474E-05
NACO3 -	3.37192E+00	4.08052E-05	NACO3 -	3.37190E+00	4.08050E-05
F -	6.17843E-01	3.26644E-05	F -	6.17843E-01	3.26644E-05
MGCO3	2.71445E+00	3.23339E-05	MGCO3	2.71439E+00	3.23331E-05
CAHCO3 +	2.99946E+00	2.98001E-05	CAHCO3 +	2.99941E+00	2.97995E-05
H3SIO4 -	1.92131E+00	2.02907E-05	H3SIO4 -	1.92133E+00	2.02908E-05
SR 2+	1.63998E+00	1.87995E-05	SR 2+	1.63998E+00	1.87995E-05
AL(OH)4 -	1.71114E+00	1.80894E-05	AL(OH)4 -	1.71114E+00	1.80894E-05
FE(OH)4 -	1.79174E+00	1.45278E-05	FE(OH)4 -	1.89406E+00	1.53575E-05
MGSO4	1.80138E+00	1.50310E-05	MGSO4	1.80135E+00	1.50308E-05
MGHCO3 +	1.08704E+00	1.27956E-05	MGHCO3 +	1.08702E+00	1.27954E-05
MN 2+	4.99737E-01	9.13654E-06	MN 2+	4.99738E-01	9.13656E-06
KSO4 -	9.25961E-01	6.88091E-06	KSO4 -	9.25963E-01	6.88093E-06
H2CO3	3.98652E-01	6.45562E-06	H2CO3	3.98649E-01	6.45558E-06
OH -	9.33412E-02	5.51250E-06	OH -	9.33418E-02	5.51253E-06
MOO4 2-	5.03437E-01	3.16156E-06	MOO4 2-	5.03437E-01	3.16156E-06
AL(OH)5 2-	2.25688E-01	2.02907E-06	AL(OH)5 2-	2.25692E-01	2.02910E-06
FE(OH)3	2.09654E-01	1.97045E-06	FE(OH)3	2.21626E-01	2.08297E-06
UO2(CO3)3 4-	8.22000E-01	1.83451E-06	UO2(CO3)3 4-	8.22001E-01	1.83451E-06
CR(OH)3	1.46351E-01	1.42691E-06	CR(OH)3	2.99286E-12	2.91801E-17
CR(OH)4 -	1.55738E-01	1.30327E-06	CR(OH)4 -	3.18482E-12	2.66518E-17
CS +	1.46000E-01	1.10338E-06	CS +	1.46000E-01	1.10338E-06
BA 2+	1.32744E-01	9.70805E-07	BA 2+	1.32744E-01	9.70805E-07
CU(OH)2	8.52646E-02	8.77824E-07	CU(OH)2	8.80314E-02	9.06309E-07
NACL	4.94403E-02	8.49695E-07	NACL	4.94403E-02	8.49696E-07
FE 2+	4.59251E-02	8.25969E-07	FE 2+	7.07058E-11	1.27165E-15

Ion speciation in leachate solution modeled using WATEQF (Plummer et al., 1976), using a mean pH of 9.1 and a temperature of 12 degrees C. See text for further discussion.

Appendix A
Aqueous Speciation of constituents in Estimated Waste-Cell Leachate

Eh = 0.0 Volts			Eh = 0.5 Volts		
SPECIES	PPM	MOLALITY	SPECIES	PPM	MOLALITY
MNHCO3 +	8.94985E-02	7.75245E-07	MNHCO3 +	8.94967E-02	7.75229E-07
ZN(CO3)2 2-	1.29407E-01	7.01076E-07	ZN(CO3)2 2-	1.29408E-01	7.01079E-07
HASO4 2-	8.85985E-02	6.35972E-07	HASO4 2-	8.85985E-02	6.35972E-07
MGF +	2.12824E-02	4.93562E-07	MGF +	2.12820E-02	4.93553E-07
CR(OH)2 +	5.23695E-02	6.11561E-07	CR(OH)2 +	1.07095E-12	1.25064E-17
NAF	1.80013E-02	4.30616E-07	NAF	1.80011E-02	4.30611E-07
HVO4 2-	3.62742E-02	3.14233E-07	HVO4 2-	3.62742E-02	3.14233E-07
NAOH	1.02805E-02	2.58165E-07	NAOH	1.02804E-02	2.58163E-07
CACL +	1.93137E-02	2.56828E-07	CACL +	1.93136E-02	2.56826E-07
MGOH +	1.04177E-02	2.53238E-07	MGOH +	1.04175E-02	2.53235E-07
CAF +	1.44848E-02	2.46262E-07	CAF +	1.44845E-02	2.46257E-07
AL(OH)3	1.89591E-02	2.44126E-07	AL(OH)3	1.89589E-02	2.44124E-07
CAOH +	8.53506E-03	1.50169E-07	CAOH +	8.53494E-03	1.50167E-07
ZNCO3	1.43310E-02	1.14797E-07	ZNCO3	1.43308E-02	1.14795E-07
KCL	8.04242E-03	1.08349E-07	KCL	8.04242E-03	1.08349E-07
FEOH +	7.21382E-03	9.94534E-08	FEOH +	1.11061E-11	1.53115E-16
LISO4 -	1.01144E-02	9.86315E-08	LISO4 -	1.01145E-02	9.86318E-08
ZN(OH)2	8.85994E-03	8.95326E-08	ZN(OH)2	8.85985E-03	8.95317E-08
HPO4 2-	7.22895E-03	7.56502E-08	HPO4 2-	7.23126E-03	7.56744E-08
PBCO3	2.00188E-02	7.52488E-08	PBCO3	2.00186E-02	7.52482E-08
MNOH +	4.59498E-03	6.41496E-08	MNOH +	4.59491E-03	6.41486E-08
SEO3 2-	8.03125E-03	6.35383E-08	SEO3 2-	3.96637E-09	3.13794E-14
AGCL	8.22030E-03	5.76091E-08	AGCL	8.22029E-03	5.76090E-08
PB(CO3)2 2-	1.75898E-02	5.39927E-08	PB(CO3)2 2-	1.75900E-02	5.39933E-08
CAPO4 -	6.54477E-03	4.86753E-08	CAPO4 -	6.54662E-03	4.86890E-08
MNSO4	6.98606E-03	4.64709E-08	MNSO4	6.98593E-03	4.64700E-08
AG +	2.72015E-03	2.53287E-08	AG +	2.72014E-03	2.53287E-08
MNCL +	2.25270E-03	2.50318E-08	MNCL +	2.25269E-03	2.50316E-08
H2VO4 -	2.43053E-03	2.08735E-08	H2VO4 -	2.43049E-03	2.08732E-08
UO2(CO3)2 2-	7.66996E-03	1.97511E-08	UO2(CO3)2 2-	7.66948E-03	1.97498E-08
CUCO3	2.24546E-03	1.82540E-08	CUCO3	2.31831E-03	1.88462E-08
MGPO4 -	2.14997E-03	1.81036E-08	MGPO4 -	2.15058E-03	1.81088E-08
H2SIO4 2-	1.68006E-03	1.79329E-08	H2SIO4 2-	1.68010E-03	1.79333E-08
CAHPO4	2.31770E-03	1.71097E-08	CAHPO4	2.31834E-03	1.71144E-08
FESO4	2.51164E-03	1.66069E-08	FESO4	3.86682E-12	2.55673E-17
KOH	8.66068E-04	1.55045E-08	KOH	8.66061E-04	1.55044E-08
CU +	9.59824E-04	1.51711E-08	CU +	1.44324E-12	2.28121E-17
ZN 2+	6.54952E-04	1.00618E-08	ZN 2+	6.54961E-04	1.00620E-08
AGCL2 -	1.70865E-03	9.59980E-09	AGCL2 -	1.70867E-03	9.59993E-09
CUCL2 -	9.97771E-04	7.45378E-09	CUCL2 -	1.50033E-12	1.12081E-17

Ion speciation in leachate solution modeled using WATEQF (Plummer et al., 1976), using a mean pH of 9.1 and a temperature of 12 degrees C. ***See text for further discussion.***

Appendix A
Aqueous Speciation of constituents in Estimated Waste-Cell Leachate

Eh = 0.0 Volts			Eh = 0.5 Volts		
SPECIES	PPM	MOLALITY	SPECIES	PPM	MOLALITY
MN(NO3)2	1.26224E-03	7.08480E-09	MN(NO3)2	1.26219E-03	7.08456E-09
CUCL	6.56438E-04	6.66003E-09	CUCL	9.87057E-13	1.00144E-17
CU(CO3)2 2-	1.19969E-03	6.56435E-09	CU(CO3)2 2-	1.23863E-03	6.77745E-09
HSEO3 -	8.18534E-04	6.42473E-09	HSEO3 -	4.04239E-10	3.17290E-15
MGHPO4	7.63872E-04	6.37822E-09	MGHPO4	7.64084E-04	6.37998E-09
FE(OH)2 +	4.32779E-04	4.83733E-09	FE(OH)2 +	4.57496E-04	5.11360E-09
ASO4 3-	6.58950E-04	4.76434E-09	ASO4 3-	6.58969E-04	4.76448E-09
H2ASO4 -	3.87543E-04	2.76194E-09	H2ASO4 -	3.87537E-04	2.76190E-09
ZNOH +	2.23975E-04	2.73057E-09	ZNOH +	2.23974E-04	2.73056E-09
NAHPO4 -	2.70604E-04	2.28462E-09	NAHPO4 -	2.70685E-04	2.28529E-09
ZNHCO3 +	2.60112E-04	2.06697E-09	ZNHCO3 +	2.60109E-04	2.06696E-09
BANO3 +	3.69232E-04	1.86050E-09	BANO3 +	3.69223E-04	1.86045E-09
CANO3 +	1.27154E-04	1.25107E-09	CANO3 +	1.27152E-04	1.25105E-09
PBOH +	2.28733E-04	1.02469E-09	PBOH +	2.28734E-04	1.02469E-09
H +	9.71697E-07	9.68242E-10	H +	9.71703E-07	9.68247E-10
MNF +	7.04473E-05	9.57017E-10	MNF +	7.04459E-05	9.56997E-10
H2PO4 -	5.56854E-05	5.76686E-10	H2PO4 -	5.57022E-05	5.76860E-10
ZNNO3 +	6.78005E-05	5.34599E-10	ZNNO3 +	6.77999E-05	5.34594E-10
LIOH	1.05336E-05	4.41823E-10	LIOH	1.05335E-05	4.41820E-10
ZN(OH)3 -	5.08938E-05	4.39155E-10	ZN(OH)3 -	5.08936E-05	4.39153E-10
CUOH +	3.30841E-05	4.12524E-10	CUOH +	3.41579E-05	4.25913E-10
PB(OH)2	9.75080E-05	4.06022E-10	PB(OH)2	9.75077E-05	4.06021E-10
AGNO3	6.82005E-05	4.03252E-10	AGNO3	6.81995E-05	4.03246E-10
SROH +	2.95709E-05	2.83878E-10	SROH +	2.95703E-05	2.83873E-10
ZNSO4	4.52244E-05	2.81365E-10	ZNSO4	4.52242E-05	2.81363E-10
KHPO4 -	3.76752E-05	2.80139E-10	KHPO4 -	3.76864E-05	2.80222E-10
FE(OH)3 -	2.65027E-05	2.49088E-10	FE(OH)3 -	4.08027E-14	3.83486E-19
ZNOHCL	2.69604E-05	2.29798E-10	ZNOHCL	2.69604E-05	2.29798E-10
FE(OH)2	1.56102E-05	1.74481E-10	FE(OH)2	2.40327E-14	2.68622E-19
HMOO4 -	2.22191E-05	1.38659E-10	HMOO4 -	2.22187E-05	1.38657E-10
AGSO4 -	2.64680E-05	1.30362E-10	AGSO4 -	2.64680E-05	1.30363E-10
CROH 2+	8.49900E-06	1.23712E-10	CROH 2+	1.73807E-16	2.52994E-21
PBHCO3 +	2.62107E-05	9.81533E-11	PBHCO3 +	2.62107E-05	9.81532E-11
PO4 3-	8.32633E-06	8.80591E-11	PO4 3-	8.32924E-06	8.80898E-11
CU(OH)3 -	9.35824E-06	8.20436E-11	CU(OH)3 -	9.66198E-06	8.47064E-11
PB 2+	1.56215E-05	7.57264E-11	PB 2+	1.56219E-05	7.57281E-11
VO4 3-	8.63026E-06	7.54171E-11	VO4 3-	8.63052E-06	7.54193E-11
CU 2+	3.76080E-06	5.94435E-11	CU 2+	3.88292E-06	6.13739E-11
FEHPO4	7.62012E-06	5.04134E-11	FEHPO4	1.17351E-14	7.76371E-20
CUHCO3 +	6.02892E-06	4.86141E-11	CUHCO3 +	6.22456E-06	5.01917E-11

Ion speciation in leachate solution modeled using WATEQF (Plummer et al., 1976), using a mean pH of 9.1 and a temperature of 12 degrees C. See text for further discussion.

Appendix A
Aqueous Speciation of constituents in Estimated Waste-Cell Leachate

Eh = 0.0 Volts			Eh = 0.5 Volts		
SPECIES	PPM	MOLALITY	SPECIES	PPM	MOLALITY
AL(OH)2 +	2.79884E-06	4.60881E-11	AL(OH)2 +	2.79884E-06	4.60881E-11
AGOH	3.20726E-06	2.57971E-11	AGOH	3.20724E-06	2.57969E-11
HF	4.96279E-07	2.49157E-11	HF	4.96276E-07	2.49155E-11
CUCL3 2-	4.21272E-06	2.49040E-11	CUCL3 2-	6.33473E-15	3.74485E-20
PBNO3 +	6.34991E-06	2.36918E-11	PBNO3 +	6.34990E-06	2.36917E-11
HSO4 -	1.88935E-06	1.95498E-11	HSO4 -	1.88936E-06	1.95499E-11
AGCL3 2-	3.51977E-06	1.65026E-11	AGCL3 2-	3.51991E-06	1.65033E-11
CAH2PO4 +	1.84222E-06	1.34996E-11	CAH2PO4 +	1.84274E-06	1.35034E-11
UO2CO3	3.40896E-06	1.03746E-11	UO2CO3	3.40868E-06	1.03738E-11
ZNCL +	1.01104E-06	1.00712E-11	ZNCL +	1.01105E-06	1.00712E-11
BAOH +	1.42119E-06	9.24841E-12	BAOH +	1.42117E-06	9.24825E-12
PB(OH)3 -	1.85895E-06	7.23082E-12	PB(OH)3 -	1.85896E-06	7.23085E-12
MNCL2	8.46711E-07	6.75796E-12	MNCL2	8.46705E-07	6.75791E-12
PBSO4	1.70290E-06	5.64007E-12	PBSO4	1.70290E-06	5.64008E-12
MGH2PO4 +	5.72431E-07	4.74000E-12	MGH2PO4 +	5.72594E-07	4.74134E-12
CUNO3 +	4.85693E-07	3.88557E-12	CUNO3 +	5.01453E-07	4.01166E-12
V2O7 4-	6.63632E-07	3.11654E-12	V2O7 4-	6.63664E-07	3.11669E-12
U(OH)5 -	7.40917E-07	2.30352E-12	U(OH)5 -	1.57142E-24	4.88558E-30
ZNF +	1.48919E-07	1.77269E-12	ZNF +	1.48918E-07	1.77268E-12
ZN(SO4)2 2-	4.30731E-07	1.68010E-12	ZN(SO4)2 2-	4.30740E-07	1.68014E-12
AGF	1.97863E-07	1.56650E-12	AGF	1.97860E-07	1.56648E-12
CUSO4	2.32550E-07	1.46344E-12	CUSO4	2.40097E-07	1.51093E-12
PBCL +	3.52103E-07	1.45746E-12	PBCL +	3.52107E-07	1.45748E-12
HV2O7 3-	1.38701E-07	6.48312E-13	HV2O7 3-	1.38702E-07	6.48317E-13
HMNO2 -	3.18962E-08	3.64272E-13	HMNO2 -	3.18957E-08	3.64266E-13
H3VO4	2.08379E-08	1.77428E-13	H3VO4	2.08374E-08	1.77424E-13
H2V2O7 2-	3.58255E-08	1.66672E-13	H2V2O7 2-	3.58247E-08	1.66669E-13
ZN(OH)4 2-	2.10445E-08	1.58440E-13	ZN(OH)4 2-	2.10448E-08	1.58443E-13
H3ASO3	1.38531E-08	1.10480E-13	H3ASO3	2.93825E-26	2.34329E-31
FEH2PO4 +	1.64541E-08	1.08135E-13	FEH2PO4 +	2.53396E-17	1.66530E-22
UO2(HPO4)2 2-	4.70916E-08	1.02383E-13	UO2(HPO4)2 2-	4.71171E-08	1.02438E-13
AGCL4 3-	2.24702E-08	9.03934E-14	AGCL4 3-	2.24719E-08	9.04002E-14
FEOH 2+	5.39072E-09	7.43197E-14	FEOH 2+	5.69869E-09	7.85656E-14
H2ASO3 -	7.62412E-09	6.12939E-14	H2ASO3 -	1.61710E-26	1.30006E-31
CUCL +	5.48892E-09	5.56890E-14	CUCL +	5.66712E-09	5.74969E-14
H3V2O7 -	9.96006E-09	4.61223E-14	H3V2O7 -	9.95968E-09	4.61205E-14
AG(OH)2 -	5.65228E-09	4.00136E-14	AG(OH)2 -	5.65227E-09	4.00135E-14
PB(OH)4 2-	1.03328E-08	3.77082E-14	PB(OH)4 2-	1.03330E-08	3.77090E-14
CU(OH)4 2-	4.88153E-09	3.72645E-14	CU(OH)4 2-	5.04005E-09	3.84746E-14
ALOH 2+	1.46350E-09	3.34165E-14	ALOH 2+	1.46352E-09	3.34171E-14

Ion speciation in leachate solution modeled using WATEQF (Plummer et al., 1976), using a mean pH of 9.1 and a temperature of 12 degrees C. See text for further discussion.

Appendix A
Aqueous Speciation of constituents in Estimated Waste-Cell Leachate

Eh = 0.0 Volts			Eh = 0.5 Volts		
SPECIES	PPM	MOLALITY	SPECIES	PPM	MOLALITY
CU2(OH)2 2+	4.60246E-09	2.86939E-14	CU2(OH)2 2+	4.90612E-09	3.05871E-14
PBHPO4	8.60234E-09	2.84990E-14	PBHPO4	8.60486E-09	2.85074E-14
MN(OH)3 -	2.97956E-09	2.82438E-14	MN(OH)3 -	2.97951E-09	2.82434E-14
CUHPO4	3.89586E-09	2.45294E-14	CUHPO4	4.02347E-09	2.53329E-14
FEH3SIO4 2+	3.32854E-09	2.21474E-14	FEH3SIO4 2+	3.51870E-09	2.34127E-14
RA 2+	4.60000E-09	2.04416E-14	RA 2+	4.60000E-09	2.04416E-14
PBF +	4.48706E-09	1.99244E-14	PBF +	4.48705E-09	1.99244E-14
PB(SO4)2 2-	7.78605E-09	1.95842E-14	PB(SO4)2 2-	7.78627E-09	1.95847E-14
V3O9 3-	5.78183E-09	1.95653E-14	V3O9 3-	5.78175E-09	1.95651E-14
CUF +	1.16114E-09	1.41289E-14	CUF +	1.19882E-09	1.45874E-14
UO2H3SIO4 +	3.83563E-09	1.05511E-14	UO2H3SIO4 +	3.83536E-09	1.05503E-14
ZNCL2	1.34653E-09	9.92381E-15	ZNCL2	1.34654E-09	9.92386E-15
UO2OH +	2.35062E-09	8.22547E-15	UO2OH +	2.35046E-09	8.22490E-15
CU2CL4 2-	1.97974E-09	7.39475E-15	CU2CL4 2-	4.47633E-27	1.67201E-32
UO2 + (5 VALEN	1.94987E-09	7.25286E-15	UO2 + (5 VALEN	2.83956E-18	1.05622E-23
CR 3+	3.38668E-10	6.54211E-15	CR 3+	6.92606E-21	1.33792E-25
ALF2 +	3.48883E-10	5.39293E-15	ALF2 +	3.48879E-10	5.39287E-15
MNCL3 -	7.40510E-10	4.61124E-15	MNCL3 -	7.40515E-10	4.61127E-15
CR3(OH)4 5+	6.77241E-10	3.03651E-15	CR3(OH)4 5+	5.79260E-42	2.59720E-47
PBCL2	8.19388E-10	2.95932E-15	PBCL2	8.19398E-10	2.95936E-15
ALF 2+	9.01809E-11	1.96997E-15	ALF 2+	9.01818E-11	1.96999E-15
H2SEO3	1.94371E-10	1.51371E-15	H2SEO3	9.59910E-17	7.47552E-22
FEF 2+	6.12781E-11	8.22344E-16	FEF 2+	6.47786E-11	8.69320E-16
ALF3	5.28175E-11	6.31731E-16	ALF3	5.28162E-11	6.31716E-16
HSE -	4.29605E-11	5.39593E-16	HSE -	2.02456E-70	2.54289E-75
MG4(OH)4 4+	8.72909E-11	5.30569E-16	MG4(OH)4 4+	8.72926E-11	5.30579E-16
CR2(OH)2 4+	5.97102E-11	4.34572E-16	CR2(OH)2 4+	2.49728E-32	1.81753E-37
H3ASO4	3.49089E-11	2.47022E-16	H3ASO4	3.49081E-11	2.47016E-16
ZN2OH 3+	3.37522E-11	2.29423E-16	ZN2OH 3+	3.37534E-11	2.29431E-16
HF2 -	3.65613E-12	1.74752E-16	HF2 -	3.65611E-12	1.74751E-16
U(OH)4	2.27988E-11	7.48207E-17	U(OH)4	4.83540E-29	1.58687E-34
HASO3 2-	7.57406E-12	6.13866E-17	HASO3 2-	1.60651E-29	1.30205E-34
UO2HPO4	2.10021E-11	5.76351E-17	UO2HPO4	2.10067E-11	5.76478E-17
FEF2 +	4.78282E-12	5.11907E-17	FEF2 +	5.05592E-12	5.41138E-17
V(OH)3	4.96009E-12	4.88607E-17	V(OH)3	1.05204E-29	1.03634E-34
H3PO4	4.36920E-12	4.47827E-17	H3PO4	4.37049E-12	4.47960E-17
UO2F +	9.30440E-12	3.23344E-17	UO2F +	9.30370E-12	3.23320E-17
CUCL2	3.43497E-12	2.56607E-17	CUCL2	3.54649E-12	2.64938E-17
VOOH +	1.91911E-12	2.29616E-17	VOOH +	2.79492E-21	3.34404E-26
UO2 2+	4.49144E-12	1.67067E-17	UO2 2+	4.49120E-12	1.67058E-17

Ion speciation in leachate solution modeled using WATEQF (Plummer et al., 1976), using a mean pH of 9.1 and a temperature of 12 degrees C. See text for further discussion.

Appendix A
Aqueous Speciation of constituents in Estimated Waste-Cell Leachate

Eh = 0.0 Volts			Eh = 0.5 Volts		
SPECIES	PPM	MOLALITY	SPECIES	PPM	MOLALITY
AL 3+	4.36401E-13	1.62455E-17	AL 3+	4.36420E-13	1.62462E-17
ZNCL3 -	2.65592E-12	1.55332E-17	ZNCL3 -	2.65597E-12	1.55335E-17
PBH2PO4 +	3.69384E-12	1.21969E-17	PBH2PO4 +	3.69495E-12	1.22006E-17
CRCL 2+	1.00995E-12	1.16001E-17	CRCL 2+	2.06540E-23	2.37226E-28
CUH2PO4 +	1.63968E-12	1.02591E-17	CUH2PO4 +	1.69340E-12	1.05952E-17
PBF2	2.15644E-12	8.83357E-18	PBF2	2.15641E-12	8.83345E-18
H2MOO4	1.01877E-12	6.31843E-18	H2MOO4	1.01875E-12	6.31828E-18
UO2F2	1.59818E-12	5.21137E-18	UO2F2	1.59804E-12	5.21092E-18
PB2OH 3+	1.64721E-12	3.83509E-18	PB2OH 3+	1.64730E-12	3.83528E-18
PBCL3 -	1.02136E-12	3.27168E-18	PBCL3 -	1.02138E-12	3.27177E-18
ALF4 -	2.44013E-13	2.38010E-18	ALF4 -	2.44008E-13	2.38004E-18
ALSO4 +	2.21894E-13	1.81134E-18	ALSO4 +	2.21894E-13	1.81135E-18
FEF3	1.07771E-13	9.59273E-19	FEF3	1.13923E-13	1.01404E-18
UO2SO4	3.05405E-13	8.37929E-19	UO2SO4	3.05382E-13	8.37868E-19
VO2 +	3.46573E-14	4.19704E-19	VO2 +	3.46567E-14	4.19697E-19
H4VO4 +	4.57846E-14	3.86539E-19	H4VO4 +	4.57838E-14	3.86532E-19
VO 2+	2.35386E-14	3.53186E-19	VO 2+	3.42814E-23	5.14376E-28
SEO4 2-	4.27668E-14	3.00478E-19	SEO4 2-	9.95778E-03	6.99630E-08
HCL	6.61742E-15	1.82294E-19	HCL	6.61746E-15	1.82295E-19
FE 3+	5.68642E-15	1.02271E-19	FE 3+	6.01146E-15	1.08117E-19
FESO4 +	7.79888E-15	5.15659E-20	FESO4 +	8.24431E-15	5.45111E-20
UO2F3 -	1.38126E-14	4.24239E-20	UO2F3 -	1.38114E-14	4.24203E-20
PB3(OH)4 2+	2.61967E-14	3.81544E-20	PB3(OH)4 2+	2.61972E-14	3.81551E-20
AL(SO4)2 -	6.44660E-15	2.95524E-20	AL(SO4)2 -	6.44664E-15	2.95525E-20
ZN2(OH)6 2-	6.34278E-15	2.73655E-20	ZN2(OH)6 2-	6.34282E-15	2.73656E-20
UO2CL +	5.37984E-15	1.76888E-20	UO2CL +	5.37951E-15	1.76877E-20
UO2(SO4)2 2-	7.51406E-15	1.63310E-20	UO2(SO4)2 2-	7.51372E-15	1.63302E-20
ZNCL4 2-	3.20297E-15	1.55272E-20	ZNCL4 2-	3.20311E-15	1.55279E-20
V(OH)2 +	5.34910E-16	6.32412E-21	V(OH)2 +	1.13456E-33	1.34136E-38
ASO3 3-	6.15942E-16	5.03305E-21	ASO3 3-	1.30649E-33	1.06757E-38
PBCL4 2-	1.08860E-15	3.13286E-21	PBCL4 2-	1.08866E-15	3.13302E-21
H2F2	1.04498E-16	2.62316E-21	H2F2	1.04497E-16	2.62313E-21
PBF3 -	5.56643E-16	2.11624E-21	PBF3 -	5.56637E-16	2.11622E-21
H2SE	1.69995E-16	2.10860E-21	H2SE	8.01117E-76	9.93697E-81
CRCL2 +	1.87853E-16	1.53523E-21	CRCL2 +	3.84164E-27	3.13958E-32
ALF5 2-	1.53693E-16	1.26562E-21	ALF5 2-	1.53691E-16	1.26560E-21
FE(SO4)2 -	2.53604E-16	1.02723E-21	FE(SO4)2 -	2.68090E-16	1.08591E-21
FECL 2+	5.72297E-17	6.29599E-22	FECL 2+	6.04997E-17	6.65573E-22
MOO2 +	7.91494E-17	6.21376E-22	MOO2 +	1.15270E-25	9.04948E-31
SE 2-	4.37757E-17	5.56851E-22	SE 2-	2.06301E-76	2.62427E-81

Ion speciation in leachate solution modeled using WATEQF (Plummer et al., 1976), using a mean pH of 9.1 and a temperature of 12 degrees C. See text for further discussion.

Appendix A
Aqueous Speciation of constituents in Estimated Waste-Cell Leachate

Eh = 0.0 Volts			Eh = 0.5 Volts		
SPECIES	PPM	MOLALITY	SPECIES	PPM	MOLALITY
CRO4 2-	5.82198E-17	5.04138E-22	CRO4 2-	3.85425E-01	3.33748E-06
VOSO4	7.44671E-17	4.58875E-22	VOSO4	1.08451E-25	6.68286E-31
U(OH)3 +	1.12456E-16	3.90770E-22	U(OH)3 +	2.38509E-34	8.28789E-40
FEHPO4 +	5.75863E-17	3.80965E-22	FEHPO4 +	6.08932E-17	4.02842E-22
VOF +	1.87099E-17	2.18672E-22	VOF +	2.72483E-26	3.18465E-31
(UO2)2(OH)2 2+	1.23239E-16	2.15623E-22	(UO2)2(OH)2 2+	1.23223E-16	2.15596E-22
CUCL3 -	1.83220E-17	1.08313E-22	CUCL3 -	1.89171E-17	1.11831E-22
SE2 2-	1.23844E-17	7.87683E-23	H2SEO4	2.34132E-17	1.62213E-22
V4O9 2-	2.20125E-17	6.35775E-23	V4O9 2-	9.90257E-53	2.86010E-58
(UO2)3(OH)5 +	4.93402E-17	5.53647E-23	(UO2)3(OH)5 +	4.93294E-17	5.53525E-23
H4ASO3 +	6.78183E-18	5.36565E-23	H4ASO3 +	1.43844E-35	1.13807E-40
UO2F4 2-	1.17273E-17	3.40414E-23	UO2F4 2-	1.17264E-17	3.40389E-23
H2SO4	1.80148E-18	1.84490E-23	H2SO4	1.80148E-18	1.84491E-23
FEH2PO4 2+	1.55319E-18	1.02075E-23	FEH2PO4 2+	1.64241E-18	1.07938E-23
FECL2 +	1.04324E-18	8.26679E-24	FECL2 +	1.10283E-18	8.73906E-24
FE2(OH)2 4+	7.97240E-19	5.49562E-24	FE2(OH)2 4+	8.90976E-19	6.14178E-24
UO2H2PO4 +	1.59390E-18	4.36206E-24	UO2H2PO4 +	1.59427E-18	4.36305E-24
AL2(OH)2 4+	8.36922E-20	9.55490E-25	AL2(OH)2 4+	8.36988E-20	9.55565E-25
V4O12 4-	2.74488E-19	6.96636E-25	V4O12 4-	2.74489E-19	6.96640E-25
HCRO4 -	7.71763E-20	6.62530E-25	HCRO4 -	5.10911E-04	4.38598E-09
VOF2	3.76326E-20	3.60202E-25	VOF2	5.48057E-29	5.24575E-34
ALF6 3-	2.16917E-20	1.54552E-25	ALF6 3-	2.16920E-20	1.54554E-25
HMOO3 +	9.59304E-21	6.64739E-26	HMOO3 +	9.59287E-21	6.64728E-26
PBF4 2-	1.38605E-20	4.91595E-26	PBF4 2-	1.38605E-20	4.91595E-26
VOH 2+	2.39841E-21	3.54532E-26	VOH 2+	5.08718E-39	7.51985E-44
HV6O17 3-	1.41562E-20	2.45724E-26	HV6O17 3-	1.41551E-20	2.45705E-26
FE3(OH)4 5+	2.16811E-21	9.24428E-27	FE3(OH)4 5+	2.56153E-21	1.09217E-26
HSEO4 -	5.65482E-22	3.94524E-27	HSEO4 -	1.31664E-10	9.18590E-16
CUCL4 2-	1.79979E-22	8.80287E-28	CUCL4 2-	1.85830E-22	9.08901E-28
FECL3	1.30862E-22	8.10327E-28	FECL3	1.38338E-22	8.56619E-28
U(OH)2 2+	9.41146E-23	3.47481E-28	U(OH)2 2+	1.99612E-40	7.36990E-46
VOF3 -	3.36711E-23	2.72881E-28	VOF3 -	4.90366E-32	3.97408E-37
H2V2O4 2+	6.56295E-24	3.92619E-29	V2(OH)2 4+	1.91254E-80	1.41356E-85
AL3(OH)4 5+	1.74939E-25	1.17948E-30	AL3(OH)4 5+	1.74960E-25	1.17962E-30
V 3+	4.92052E-26	9.70182E-31	V 3+	1.04370E-43	2.05788E-48
UO2(H2PO4)2	4.03178E-25	8.72750E-31	UO2(H2PO4)2	4.03386E-25	8.73201E-31
MN 3+	5.76598E-27	1.05418E-31	MN 3+	3.95923E-18	7.23853E-23
U(HPO4)4 4-	1.70461E-27	2.75287E-33	U(HPO4)4 4-	3.61994E-45	5.84605E-51
H2V6O17 2-	6.63413E-28	1.14955E-33	H2V6O17 2-	6.63340E-28	1.14942E-33
H2SEO4	1.00558E-28	6.96692E-34			

Ion speciation in leachate solution modeled using WATEQF (Plummer et al., 1976), using a mean pH of 9.1 and a temperature of 12 degrees C. See text for further discussion.

Appendix A
Aqueous Speciation of constituents in Estimated Waste-Cell Leachate

Eh = 0.0 Volts			Eh = 0.5 Volts		
SPECIES	PPM	MOLALITY	SPECIES	PPM	MOLALITY
MOO2 2+	6.78321E-29	5.32528E-34	MOO2 2+	6.78321E-29	5.32528E-34
VOH +	3.81920E-30	5.64552E-35	VOH +	1.17976E-56	1.74392E-61
UOH 3+	1.22294E-29	4.81632E-35	UOH 3+	2.59386E-47	1.02155E-52
H2CRO4	3.10199E-30	2.64020E-35	H2CRO4	2.05352E-14	1.74782E-19
U(HPO4)3 2-	1.10978E-29	2.11929E-35	U(HPO4)3 2-	2.35588E-47	4.49891E-53
V 2+	4.41282E-31	8.70079E-36	V 2+	1.36316E-57	2.68775E-62
PB(OH)6 2-	4.60697E-31	1.49633E-36	PB(OH)6 2-	2.17206E-13	7.05479E-19
U(HPO4)2	1.79503E-31	4.19304E-37	U(HPO4)2	3.80934E-49	8.89829E-55
SIF6 2-	5.59232E-32	3.95353E-37	SIF6 2-	5.59228E-32	3.95350E-37
UO2(H2PO4)3 -	2.60205E-32	4.65881E-38	UO2(H2PO4)3 -	2.60419E-32	4.66263E-38
UF2 2+	5.00518E-33	1.82130E-38	UF2 2+	1.06156E-50	3.86286E-56
UF3 +	3.63191E-33	1.23649E-38	UF3 +	7.70285E-51	2.62245E-56
UF4	3.38219E-33	1.08181E-38	UF4	7.17313E-51	2.29436E-56
UF 3+	8.16813E-34	3.19196E-39	UF 3+	1.73246E-51	6.77015E-57
UHPO4 2+	7.46342E-34	2.24437E-39	UHPO4 2+	1.58343E-51	4.76161E-57
U(SO4)2	8.23956E-36	1.92399E-41	U(SO4)2	1.74754E-53	4.08062E-59
UF5 -	4.42369E-36	1.33422E-41	UF5 -	9.38202E-54	2.82968E-59
USO4 2+	3.34529E-36	1.00574E-41	USO4 2+	7.09522E-54	2.13314E-59
U 4+	3.99321E-37	1.68502E-42	U 4+	8.47000E-55	3.57410E-60
UF6 2-	7.54603E-38	2.15311E-43	UF6 2-	1.60043E-55	4.56649E-61
UCL 3+	1.40145E-39	5.14708E-45	UCL 3+	2.97251E-57	1.09171E-62
CR2O7 2-	7.32216E-42	3.40505E-47	CR2O7 2-	3.20898E-10	1.49228E-15
MO 3+	4.09938E-44	4.29172E-49	MO 3+	1.26637E-70	1.32579E-75
V2(OH)2 4+	4.25093E-45	3.14185E-50	H2V2O4 2+	1.39201E-41	8.32752E-47
U 3+	2.42153E-47	1.02182E-52	U 3+	7.48016E-74	3.15641E-79
MNO4 2-	2.38971E-51	2.01812E-56	MNO4 2-	5.31177E-16	4.48581E-21
V10O28 6-	1.40982E-51	1.47906E-57	V10O28 6-	1.40980E-51	1.47904E-57
PB(OH)8 4-	1.58176E-52	4.62842E-58	PB(OH)8 4-	7.45809E-35	2.18233E-40
HV10O28 5-	1.83567E-55	1.92380E-61	HV10O28 5-	1.83553E-55	1.92365E-61
MNO4 -	7.03952E-62	5.94489E-67	MNO4 -	1.07437E-17	9.07307E-23
PB 4+	9.02677E-62	4.37578E-67	PB 4+	4.25617E-44	2.06320E-49
H2V10O28 4-	1.12304E-61	1.17571E-67	H2V10O28 4-	1.12289E-61	1.17556E-67

Ion speciation in leachate solution modeled using WATEQF (Plummer et al., 1976), using a mean pH of 9.1 and a temperature of 12 degrees C. See text for further discussion.

To
Wayne Belcher
RMRS T893B
Fx 7193

From
Leon Collins - RMRS
X 6?00
3/25/96

FAX MEMO
PAGES ____ DATE ____ FAX # ____
TO ____
FROM ____
CC ____
PH # ____ FAX # ____

6 Pages

output filename Rain100L.out
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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 100

	INCHES		CU. FEET	PERCENT
PRECIPITATION	15.44	(2.909)	560443.0	100.00
RUNOFF	0.060	(0.0993)	2176.92	0.388
EVAPOTRANSPIRATION	14.299	(2.5270)	519043.47	92.613
LATERAL DRAINAGE COLLECTED FROM LAYER 6	1.08088	(0.64998)	39236.066	7.00090
PERCOLATION/LEAKAGE THROUGH FROM LAYER 8	0.00000	(0.00000)	0.135	0.00002
AVERAGE HEAD ACROSS TOP OF LAYER 8	0.001	(0.001)		
Waste Layer is #10				
LATERAL DRAINAGE COLLECTED FROM LAYER 13 Concrete Slab	0.00000	(0.00000)	0.000	0.00000
PERCOLATION/LEAKAGE THROUGH FROM LAYER 14	0.00000	(0.00000)	0.[illegible]	0.00[illegible]
AVERAGE HEAD ACROSS TOP OF LAYER 14	0.000	(0.000)		
LATERAL DRAINAGE COLLECTED FROM LAYER 15	0.00000	(0.00000)	0.051	0.00001
PERCOLATION/LEAKAGE THROUGH FROM LAYER 17	0.00000	(0.00000)	0.0845	0.00001

INITIAL SOIL WATER CONTENT = 0.1591 VOL/VOL
EFFECTIVE SAT. HYD. COND. = 0.370000005000E-01 CM/SEC

LAYER 10

TYPE 1 - VERTICAL PERCOLATION LAYER - *compacted Waste*
MATERIAL TEXTURE NUMBER 19

THICKNESS	=	204.00 INCHES
POROSITY	=	0.1680 VOL/VOL
FIELD CAPACITY	=	0.0730 VOL/VOL
WILTING POINT	=	0.0190 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0730 VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.100000005000E-02 CM/SEC

LAYER 11

TYPE 1 - VERTICAL PERCOLATION LAYER - *drainage net.*
MATERIAL TEXTURE NUMBER 20

THICKNESS	=	0.20 INCHES
POROSITY	=	0.8500 VOL/VOL
FIELD CAPACITY	=	0.0100 VOL/VOL
WILTING POINT	=	0.0050 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0100 VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	10.0000000000 CM/SEC

LAYER 12

TYPE 1 - VERTICAL PERCOLATION LAYER - *Concrete slab with drain Piles*
MATERIAL TEXTURE NUMBER 43

THICKNESS	=	[illegible] INCHES
POROSITY	=	0.3600 VOL/VOL
FIELD CAPACITY	=	0.0358 VOL/VOL
WILTING POINT	=	0.0210 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0358 VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	3.30900002000 CM/SEC

LAYER 13

TYPE 2 - LATERAL DRAINAGE LAYER - *Gravel under Slab*
MATERIAL TEXTURE NUMBER 43

THICKNESS	=	12.00 INCHES
POROSITY	=	0.3600 VOL/VOL
FIELD CAPACITY	=	0.0358 VOL/VOL
WILTING POINT	=	0.0210 VOL/VOL

INITIAL SOIL WATER CONTENT	=	0.0358	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	3.30900002000	CM/SEC
SLOPE	=	1.00	PERCENT
DRAINAGE LENGTH	=	235.0	FEET

LAYER 14

TYPE 4 - FLEXIBLE MEMBRANE LINER — Leachate Collection Membrane

MATERIAL TEXTURE NUMBER 35

THICKNESS	=	0.08	INCHES
POROSITY	=	0.0000	VOL/VOL
FIELD CAPACITY	=	0.0000	VOL/VOL
WILTING POINT	=	0.0000	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0000	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.199999996000E-12	CM/SEC
FML PINHOLE DENSITY	=	2.00	HOLES/ACRE
FML INSTALLATION DEFECTS	=	2.00	HOLES/ACRE
FML PLACEMENT QUALITY	=	4 - POOR	

LAYER 15

TYPE 2 - LATERAL DRAINAGE LAYER — Geocomposite

MATERIAL TEXTURE NUMBER 20

THICKNESS	=	1.00	INCHES
POROSITY	=	0.8500	VOL/VOL
FIELD CAPACITY	=	0.0100	VOL/VOL
WILTING POINT	=	0.0050	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0100	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	10.0000000000	CM/SEC
SLOPE	=	1.00	PERCENT
DRAINAGE LENGTH	=	235.0	FEET

LAYER 16

TYPE 4 - FLEXIBLE MEMBRANE LINER — Leak detection Membrane

MATERIAL TEXTURE NUMBER 35

THICKNESS	=	0.08	INCHES
POROSITY	=	0.0000	VOL/VOL
FIELD CAPACITY	=	0.0000	VOL/VOL
WILTING POINT	=	0.0000	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0000	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.199999996000E-12	CM/SEC
FML PINHOLE DENSITY	=	2.00	HOLES/ACRE
FML INSTALLATION DEFECTS	=	2.00	HOLES/ACRE
FML PLACEMENT QUALITY	=	4 - POOR	

LAYER 17

TYPE 3 - BARRIER SOIL LINER — Bottom Clay
MATERIAL TEXTURE NUMBER 16

THICKNESS	=	36.00	INCHES
POROSITY	=	0.4270	VOL/VOL
FIELD CAPACITY	=	0.4180	VOL/VOL
WILTING POINT	=	0.3670	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.4270	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.100000001000E-06	CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT SOIL DATA BASE USING SOIL TEXTURE # 1 WITH A POOR STAND OF GRASS, A SURFACE SLOPE OF 3.% AND A SLOPE LENGTH OF 235. FEET.

SCS RUNOFF CURVE NUMBER	=	64.60	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	10.000	ACRES — actually only 4½ acres per 100K yd³ cell
EVAPORATIVE ZONE DEPTH	=	18.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	0.939	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	7.438	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	0.828	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	49.658	INCHES
TOTAL INITIAL WATER	=	49.658	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR — Above Grade

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
DENVER COLORADO

MAXIMUM LEAF AREA INDEX	=	1.80	
START OF GROWING SEASON (JULIAN DATE)	=	139	
END OF GROWING SEASON (JULIAN DATE)	=	254	
AVERAGE ANNUAL WIND SPEED	=	8.80 MPH	slow!
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	54.00 %	wet
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	50.00 %	
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	49.00 %	∴ conservative for site.
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	54.00 %	

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING COEFFICIENTS FOR DENVER COLORADO

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 100

	(INCHES)	(CU. FT.)
PRECIPITATION	2.49	90387.000
RUNOFF	0.392	14236.7549
DRAINAGE COLLECTED FROM LAYER 6	0.58248	21143.84180
PERCOLATION/LEAKAGE THROUGH LAYER 8	0.000001	0.01920
AVERAGE HEAD ACROSS LAYER 8	0.330	
DRAINAGE COLLECTED FROM LAYER 13	0.00000	0.00001
PERCOLATION/LEAKAGE THROUGH LAYER 14	0.000000	0.00377
AVERAGE HEAD ACROSS LAYER 14	0.000	
DRAINAGE COLLECTED FROM LAYER 15	0.00000	0.00345
PERCOLATION/LEAKAGE THROUGH LAYER 17	0.000000	0.00025
AVERAGE HEAD ACROSS LAYER 17	0.000	
SNOW WATER	1.55	56425.5508

MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.2237
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.0370

****

0.00025 ft^3/day

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**                                                                          **
**                                                                          **
**            HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE                 **
**             HELP MODEL VERSION 3.01   (14 OCTOBER 1994)                  **
**               DEVELOPED BY ENVIRONMENTAL LABORATORY                      **
**                 USAE WATERWAYS EXPERIMENT STATION                        **
**           FOR USEPA RISK REDUCTION ENGINEERING LABORATORY                **
**                                                                          **
**                                                                          **
******************************************************************************
******************************************************************************


PRECIPITATION DATA FILE:      C:\HELP3\RAIN100.D4
TEMPERATURE DATA FILE:        C:\HELP3\RAIN100.D7
SOLAR RADIATION DATA FILE:    C:\HELP3\RAIN100.D13
EVAPOTRANSPIRATION DATA:      C:\HELP3\RAIN100.D11
SOIL AND DESIGN DATA FILE:    C:\HELP3\RAIN18.D10
OUTPUT DATA FILE:             C:\HELP3\RAIN100N.OUT


TIME:  11:18     DATE:   4/ 7/1996


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     TITLE:  interim cover (no cover)

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     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
            COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.


                                 LAYER  1
                                 --------

                      TYPE 1 - VERTICAL PERCOLATION LAYER
                         MATERIAL TEXTURE NUMBER   2
          THICKNESS                     =      12.00  INCHES
          POROSITY                      =      0.4370 VOL/VOL
          FIELD CAPACITY                =      0.0620 VOL/VOL
          WILTING POINT                 =      0.0240 VOL/VOL
          INITIAL SOIL WATER CONTENT    =      0.0495 VOL/VOL
          EFFECTIVE SAT. HYD. COND.     =   0.579999993000E-02 CM/SEC
        NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  1.80
               FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.
```

LAYER 2

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 2

THICKNESS	=	12.00	INCHES
POROSITY	=	0.4370	VOL/VOL
FIELD CAPACITY	=	0.0620	VOL/VOL
WILTING POINT	=	0.0240	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0572	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.579999993000E-02	CM/SEC

LAYER 3

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 2

THICKNESS	=	1.00	INCHES
POROSITY	=	0.4370	VOL/VOL
FIELD CAPACITY	=	0.0620	VOL/VOL
WILTING POINT	=	0.0240	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0981	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.579999993000E-02	CM/SEC

LAYER 4

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 16

THICKNESS	=	6.00	INCHES
POROSITY	=	0.4270	VOL/VOL
FIELD CAPACITY	=	0.4180	VOL/VOL
WILTING POINT	=	0.3670	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.4178	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.100000001000E-06	CM/SEC

LAYER 5

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 19

THICKNESS	=	204.00	INCHES
POROSITY	=	0.1680	VOL/VOL
FIELD CAPACITY	=	0.0730	VOL/VOL
WILTING POINT	=	0.0190	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0730	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.100000005000E-02	CM/SEC

LAYER 6

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 20

THICKNESS	=	0.20	INCHES
POROSITY	=	0.8500	VOL/VOL
FIELD CAPACITY	=	0.0100	VOL/VOL
WILTING POINT	=	0.0050	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0703	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	10.0000000000	CM/SEC

LAYER 7

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 43

THICKNESS	=	12.00	INCHES
POROSITY	=	0.3600	VOL/VOL
FIELD CAPACITY	=	0.0358	VOL/VOL
WILTING POINT	=	0.0210	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0522	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	3.30900002000	CM/SEC

LAYER 8

TYPE 2 - LATERAL DRAINAGE LAYER
MATERIAL TEXTURE NUMBER 43

THICKNESS	=	12.00	INCHES
POROSITY	=	0.3600	VOL/VOL
FIELD CAPACITY	=	0.0358	VOL/VOL
WILTING POINT	=	0.0210	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0358	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	3.30900002000	CM/SEC
SLOPE	=	3.00	PERCENT
DRAINAGE LENGTH	=	235.0	FEET

LAYER 9

TYPE 4 - FLEXIBLE MEMBRANE LINER
MATERIAL TEXTURE NUMBER 35

THICKNESS	=	0.08	INCHES
POROSITY	=	0.0000	VOL/VOL
FIELD CAPACITY	=	0.0000	VOL/VOL
WILTING POINT	=	0.0000	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0000	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.199999996000E-12	CM/SEC
FML PINHOLE DENSITY	=	2.00	HOLES/ACRE

FML INSTALLATION DEFECTS	=	2.00 HOLES/ACRE
FML PLACEMENT QUALITY	=	4 - POOR

LAYER 10

TYPE 2 - LATERAL DRAINAGE LAYER
MATERIAL TEXTURE NUMBER 20

THICKNESS	=	1.00 INCHES
POROSITY	=	0.8500 VOL/VOL
FIELD CAPACITY	=	0.0100 VOL/VOL
WILTING POINT	=	0.0050 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0100 VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	10.0000000000 CM/SEC
SLOPE	=	1.00 PERCENT
DRAINAGE LENGTH	=	235.0 FEET

LAYER 11

TYPE 4 - FLEXIBLE MEMBRANE LINER
MATERIAL TEXTURE NUMBER 35

THICKNESS	=	0.08 INCHES
POROSITY	=	0.0000 VOL/VOL
FIELD CAPACITY	=	0.0000 VOL/VOL
WILTING POINT	=	0.0000 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0000 VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.199999996000E-12 CM/SEC
FML PINHOLE DENSITY	=	2.00 HOLES/ACRE
FML INSTALLATION DEFECTS	=	2.00 HOLES/ACRE
FML PLACEMENT QUALITY	=	4 - POOR

LAYER 12

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 16

THICKNESS	=	36.00 INCHES
POROSITY	=	0.4270 VOL/VOL
FIELD CAPACITY	=	0.4180 VOL/VOL
WILTING POINT	=	0.3670 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.4270 VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.100000001000E-06 CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT SOIL DATA BASE USING SOIL TEXTURE # 2 WITH A POOR STAND OF GRASS, A SURFACE SLOPE OF 3.% AND A SLOPE LENGTH OF 235. FEET.

SCS RUNOFF CURVE NUMBER	=	73.10	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	10.000	ACRES
EVAPORATIVE ZONE DEPTH	=	18.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	0.740	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	7.866	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	0.432	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	35.229	INCHES
TOTAL INITIAL WATER	=	35.229	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM DENVER COLORADO

MAXIMUM LEAF AREA INDEX	=	1.00	
START OF GROWING SEASON (JULIAN DATE)	=	137	
END OF GROWING SEASON (JULIAN DATE)	=	254	
AVERAGE ANNUAL WIND SPEED	=	8.80	MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	54.00	%
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	50.00	%
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	49.00	%
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	54.00	%

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING COEFFICIENTS FOR DENVER COLORADO

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
0.51	0.69	1.21	1.81	2.47	1.58
1.93	1.53	1.23	0.98	0.82	0.55

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING COEFFICIENTS FOR DENVER COLORADO

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
29.50	33.60	38.00	47.40	57.20	67.00
73.30	71.40	62.60	51.90	38.70	32.60

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING COEFFICIENTS FOR DENVER COLORADO

STATION LATITUDE = 39.77 DEGREES

****

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 100

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	0.53	0.78	1.25	1.75	2.39	1.60
	2.01	1.48	1.32	0.92	0.80	0.61
STD. DEVIATIONS	0.37	0.44	0.66	0.98	1.21	0.94
	1.12	0.84	0.88	0.71	0.55	0.36
RUNOFF						
TOTALS	0.006	0.028	0.023	0.000	0.001	0.000
	0.000	0.000	0.000	0.000	0.000	0.004
STD. DEVIATIONS	0.020	0.076	0.066	0.000	0.005	0.001
	0.000	0.000	0.001	0.000	0.002	0.018
EVAPOTRANSPIRATION						
TOTALS	0.549	0.592	1.076	1.521	2.096	1.703
	2.215	1.372	1.217	0.763	0.717	0.613
STD. DEVIATIONS	0.262	0.338	0.465	0.688	0.913	0.826
	0.932	0.767	0.693	0.512	0.440	0.306
LATERAL DRAINAGE COLLECTED FROM LAYER 8						
TOTALS	0.0521	0.0451	0.0464	0.0415	0.0393	0.0353
	0.0414	0.0479	0.0530	0.0563	0.0548	0.0554
STD. DEVIATIONS	0.0224	0.0211	0.0243	0.0247	0.0263	0.0267
	0.0264	0.0254	0.0190	0.0187	0.0177	0.0198
PERCOLATION/LEAKAGE THROUGH LAYER 9						
TOTALS	0.0325	0.0284	0.0299	0.0272	0.0262	0.0232
	0.0265	0.0295	0.0325	0.0343	0.0335	0.0340
STD. DEVIATIONS	0.0102	0.0095	0.0110	0.0114	0.0126	0.0137
	0.0136	0.0133	0.0089	0.0085	0.0076	0.0085

LATERAL DRAINAGE COLLECTED FROM LAYER 10

TOTALS	0.0325	0.0284	0.0299	0.0272	0.0262	0.0232
	0.0265	0.0295	0.0325	0.0343	0.0335	0.0340
STD. DEVIATIONS	0.0102	0.0095	0.0110	0.0114	0.0125	0.0137
	0.0136	0.0133	0.0089	0.0085	0.0076	0.0085

PERCOLATION/LEAKAGE THROUGH LAYER 12

TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ACROSS LAYER 9

AVERAGES	0.0010	0.0010	0.0009	0.0009	0.0008	0.0008
	0.0008	0.0010	0.0011	0.0011	0.0011	0.0011
STD. DEVIATIONS	0.0004	0.0004	0.0004	0.0005	0.0005	0.0005
	0.0005	0.0005	0.0004	0.0003	0.0003	0.0004

DAILY AVERAGE HEAD ACROSS LAYER 12

AVERAGES	0.0004	0.0004	0.0004	0.0004	0.0004	0.0003
	0.0004	0.0004	0.0004	0.0005	0.0005	0.0005
STD. DEVIATIONS	0.0001	0.0001	0.0001	0.0002	0.0002	0.0002
	0.0002	0.0002	0.0001	0.0001	0.0001	0.0001

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 100

	INCHES	CU. FEET	PERCENT
PRECIPITATION	15.44 (2.909)	560443.0	100.00
RUNOFF	0.062 (0.0998)	2251.85	0.402
EVAPOTRANSPIRATION	14.434 (2.5623)	523949.44	93.488
LATERAL DRAINAGE COLLECTED FROM LAYER 8	0.56843 (0.21235)	20634.100	3.68175
ERCOLATION/LEAKAGE THROUGH FROM LAYER 9	0.35784 (0.09918)	12989.652	2.31775
AVERAGE HEAD ACROSS TOP OF LAYER 9	0.001 (0.000)		

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 100

	(INCHES)	(CU. FT.)
PRECIPITATION	2.49	90387.000
RUNOFF	0.394	14310.1660
DRAINAGE COLLECTED FROM LAYER 8	0.00395	143.20885
PERCOLATION/LEAKAGE THROUGH LAYER 9	0.001778	64.55125
AVERAGE HEAD ACROSS LAYER 9	0.002	
DRAINAGE COLLECTED FROM LAYER 10	0.00169	61.37564
PERCOLATION/LEAKAGE THROUGH LAYER 12	0.000000	0.00078
AVERAGE HEAD ACROSS LAYER 12	0.001	
SNOW WATER	1.55	56425.5508
MAXIMUM VEG. SOIL WATER (VOL/VOL)		0.1896
MINIMUM VEG. SOIL WATER (VOL/VOL)		0.0146

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FINAL WATER STORAGE AT END OF YEAR 100

LAYER	(INCHES)	(VOL/VOL)
1	0.3697	0.0308
2	1.8921	0.1577
3	0.4370	0.4370
4	2.5620	0.4270
5	14.8920	0.0730
6	0.0160	0.0800
7	0.9514	0.0793
8	0.4296	0.0358
9	0.0000	0.0000
10	0.0104	0.0104
11	0.0000	0.0000
12	15.3720	0.4270
SNOW WATER	0.000	

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Attachment 1. Fugitive Dust Emission Supplement

Air modeling was conducted to provide individual specific activity limits of radionuclides in soils that would trigger the 10 millirem (mrem) effective dose equivalent and to provide an estimate of particulate dust emissions generated from wind erosion to the nearest receptor at 96th Avenue and Indiana Street.

The individual tolerance specific activity limits are reported in picocuries per gram of soils (pCi/g). The average annual concentration of fugitive dust emissions are reported in grams per cubic meter of air (g/m^3).

The following conservative assumptions were used to calculate the limits identified above:

- The RWSF is five acres in area with the total area being exposed;
- No operational cover or soil cover was assumed;
- 1995 RFETS meteorological data was used;
- The fugitive dust emission factors were calculated using a procedure developed by the U. S. EPA Office of air Quality, Planning and Standards, Research Triangle Park, North Carolina. "Compilation of Air Pollutant Emission Factors", AP-42, January 1995;
- 3,962 meters from the RWSF site to a receptor at 96th and Indiana;
- The total disturbed, erodable surface area is 20,234 square meters;
- The emission factor for fugitive dust from wind erosion is 66.84 grams per square meter for one year;

Annual Average Concentration of Fugitive Dust.

The average annual concentration of re-suspended fugitive dust generated from wind erosion of a five acre RWSF to a receptor at 96th and Indiana is 1.00-E08 g/m^3.

Estimation of Individual Specific Activity Limits.

Individual specific activity limits for radionuclides in soil were calculated for Pu-239/240, Am-241, U-234, and U-238. These limits were based upon the following parameters:

- The limits were calculated using the computer dispersion model CAP88PC;
- The limits are individual isotope specific limits and assume 100% contribution from the specific isotope;
- Variable contributions to the total limit of 10 mrem were assessed : 9.984 mrem (10 mrem - 1996 plant contribution), 1 mrem, 5 mrem, and .5 mrem;

The following four calculations represent the isotope specific limit scenarios described above.

Calculation of Soil Activity for RWSF Based on Dose Limit at Plant Boundary

Assume Plant contribution is 0.0156 mrem/year based on projections for 1996. This is twice the 1995 value.

For the 10 mrem/year limit, subtracting out the plant contribution would yield 9.984 mrem/year limit for the RWSF.

Emissivity =	**66.84**	**$g/m^2/yr$**
Area of RWSF=	**20234**	**m^2**
Dose Limit =	**10**	**mrem/year (at Plant boundary)**
Plant Contribution =	**0.0156**	**mrem/year (at Plant boundary)**
Adjusted Dose =	**9.9844**	**mrem/year (at Plant boundary)**

Isotope	**Specific Activity of Isotope (Ci/g)**	**Calculaiton of Radionuclide in air mass above RWSF** y-intercept	**slope**	**(g/year)**	**Specific Activity in Soils (Ci/g)**	**Specific Activity in Soils (pCi/g)**
Pu-139	0.0576	0.002	0.528	5.273763	2.24608E-07	224608
Am-241	6.00E-04	-0.182	50	499.038	2.21394E-07	221394
U-234	3.70E-08	1.00E-07	3418400	34130673	9.33745E-07	933745
U-238	3.40E-07	-135	418420	4177538	1.05022E-06	1050222

For a 1 mrem /year limit:

Emissivity =	**66.84**	**$g/m^2/yr$**
Area of RWSF=	**20234**	**m^2**
Dose Limit =	**1**	**mrem/year (at Plant boundary)**
Plant Contribution =	**0.0156**	**mrem/year (at Plant boundary)**
Adjusted Dose =	**0.9844**	**mrem/year (at Plant boundary)**

Calculaiton of Radionuclide in air mass above RWSF

Isotope	**Specific Activity of Isotope (Ci/g)**	**y-intercept**	**slope**	**(g/year)**	**Specific Activity in Soils (Ci/g)**	**Specific Activity in Soils (pCi/g)**
Pu-139	0.0576	0.002	0.528	0.521763	2.22217E-08	22222
Am-241	6.00E-04	-0.182	50	49.038	2.17553E-08	21755
U-234	3.70E-08	1.00E-07	3418400	3365073	9.20615E-08	92061
U-238	3.40E-07	-135	418420	411757.6	1.03515E-07	103515

For a 5 mrem /year limit:

Emissivity =	**66.84**	**$g/m^2/yr$**
Area of RWSF=	**20234**	**m^2**
Dose Limit =	**5**	**mrem/year (at Plant boundary)**
Plant Contribution =	**0.0156**	**mrem/year (at Plant boundary)**
Adjusted Dose =	**4.9844**	**mrem/year (at Plant boundary)**

Isotope	Specific Activity of Isotope (Ci/g)	Calculaiton of Radionuclide in air mass above RWSF y-intercept	slope	(g/year)	Specific Activity in Soils (Ci/g)	Specific Activity in Soils (pCi/g)
Pu-139	0.0576	0.002	0.528	2.633763	1.12171E-07	112171
Am-241	6.00E-04	-0.182	50	249.038	1.10484E-07	110484
U-234	3.70E-08	1.00E-07	3418400	17038673	4.66143E-07	466143
U-238	3.40E-07	-135	418420	2085438	5.24274E-07	524274

For a 0.5 mrem /year limit:

Emissivity =	**66.84 $g/m^2/yr$**
Area of RWSF=	**20234 m^2**
Dose Limit =	**0.5 mrem/year (at Plant boundary)**
Plant Contribution =	**0.0156 mrem/year (at Plant boundary)**
Adjusted Dose =	**0.4844 mrem/year (at Plant boundary)**

Isotope	Specific Activity of Isotope (Ci/g)	Calculaiton of Radionuclide in air mass above RWSF y-intercept	slope	(g/year)	Specific Activity in Soils (Ci/g)	Specific Activity in Soils (pCi/g)
Pu-139	0.0576	0.002	0.528	0.257763	1.09781E-08	10978
Am-241	6.00E-04	-0.182	50	24.038	1.06643E-08	10664
U-234	3.70E-08	1.00E-07	3418400	1655873	4.53013E-08	45301
U-238	3.40E-07	-135	418420	202547.6	5.09199E-08	50920

Table H-1 ***Summary of Criteria Used to Evaluate Environmental Impacts***[1]

Criteria	Included in Siting Study (Sections in Appendix C)	Included in Facility Design Screen (Criteria in Section 5.2 and Appendix F)	Included in Final Comparison (Section 6.0)	Included in OU 4 February Decision Document
Human Health		Criteria 1.1, 1.2, 1.4, 2.1, & 6.6	NCP threshold: human health & regulatory requirements	§IV.10.1
Environment	§C2.4.1, §C2.4.3	Broken into the following criteria	NCP threshold: human health & regulatory requirements	Table IV.10-22
Ecological Risk	§C2.4.1			§IV.10.2
Air Quality		Criterion 6.5		§IV.10.3
Water Quality	§C2.4.1	Criteria 2.1, 2.5, 2.10, 2.11, & 2.12		§IV.10.4, §IV.10.5
Soils & Sediments				
Irretrievable/Irreversible Commitment of Resources	§C2.4.2, §C2.4.4, §C2.4.6	Criteria 3.8 & 5.6		§IV.10.6
Natural Phenomenon Mitigation/ Mitigation Measures	§C2.4.1	Criteria 2.2 & 2.3		§IV.10.7
Transportation	§C2.4.2			§IV.10.8
Short-term vs. Long-term	§C2.4.1, §C2.4.2, §C2.4.3	Criteria 1.5, 1.6, & 6.7	NCP primary balancing: long-term and short-term effectiveness, treatment	§IV.10.9
Cultural/archeological Resources				§IV.10.10
Cumulative Impacts	§C2.4.2	Criteria 3.1 & 3.9		§IV.10.11
Direct/Indirect Effects[2]				Table IV.10-22

1) This table identifies the selection in this Decision Document containing criteria used to evaluate the NEPA-values in the Remediation Waste Storage Facility Siting Study. For the *Facility Design Screen, the numeric* designation of the criterion is shown. For the final comparison, the related NCP criteria are listed. The Solar Ponds location was evaluated in the OU 4 February Proposed Decision Document, and the sections where the criteria are discussed are also indicated. Additional criteria were also used *in some of the studies (for* example, cost); for a complete listing of the criteria used in each study, see the appropriate document section.

2) Direct effects which occur at the same time and place as an action and indirect effects which occur at a later time and greater distance are generally considered by medium in this criterion

Table H-2 Summary of Results: Evaluation of Environmental Impacts Remediation Waste Storage Facility Siting Study[1]

Criteria	Potential Impacts for Onsite Locations	Specific to Proposed Location at Solar Ponds Area
Environment	• All sites have approximately the same geomorphic conditions with the degree of erosion occurring at a predictable rate. (§2.4.2 Public Protection) • A reliable, effective, and protective facility can be engineered at any of the sites being considered. (§2.4.1 CAMU)	none noted
Ecological Risk	• The presence of significant springs and seeps in certain Buffer Zone sites reduces their suitability because of potential impacts to sensitive habitats. (§2.4.2 Public Protection)	none noted
Ground Water Quality	• All the sites are located in recharge areas. (§2.4.2 Public Protection) • All of the sites have minimal groundwater flow. (§2.4.2 Public Protection) • Downward migration from the unconfined aquifer is thought to be nonexistent.. (§2.4.2 Public Protection) • Groundwater flow in fractured claystone bedrock is thought to be minimal. (§2.4.2 Public Protection) • The sites have seasonally shallow water tables that may require engineered barriers. (§2.4.2 Public Protection)	• Local variations in shallow bedrock lithology at the Solar Ponds area is caused by subcropping sandstones, but vertical flow to deeper sandstones and the Laramie/Fox Hills aquifer is minimal. (§2.4.2 Public Protection)

[1]This table summarized the results of the evaluations for the Onsite Remediation Waste Storage Facility Siting Study. References in the table indicate the section of the study where discussion of the criteria are found.

Table H-2 (continued)

Criteria	Potential Impacts for Onsite Locations	Specific to Proposed Location at Solar Ponds Area
Surface Water Quality	• Estimates of lateral groundwater travel times from the proposed sites to their nearest discharge pints are well below 1,000 years. (§2.4.2 Public Protection) • None of the sites are located in areas that will be impacted by surface water. The sites are not expected to have a significant impact on surface water. (§2.4.2 Public Protection)	none noted
Irretrievable/ Irreversible Commitment of Resources	• Alluvial thicknesses greater than 40 feet are potentially economic for the gravel resource. Portions of the Buffer Zone have alluvial thicknesses of 40 feet or more. (§2.4.3 RFETS Special Issues) • Minimization of the land area upon which remediation wastes would remain in place is generally dependent on the design selected rather than location. (§2.4.3 RFETS Special Issues) • Jefferson County has stated a desire to maintain the Buffer Zone as undeveloped open space; sites in the Buffer Zone would impinge on this. (§2.4.6 Other Stakeholder Concerns)	• Solar Ponds area do not constitute an economical gravel resource. (§2.4.3 RFETS Special Issues) • The Solar Ponds site coincides with the Site Vision by locating the WMF within the larger footprint of the final cap cove. (§2.4.3 RFETS Special Issues & §2.4.4 Regulator Support) • Sites within the Industrial Area, including the Solar Ponds area, would be more readily acceptable. (§2.4.6 Other Stakeholder Concerns)
Natural Phenomenon Mitigation/ Mitigation Measures	• Geotechnical stability of foundation soils is not expected to be a problem at any of the sites. (§2.4.2 Public Protection) • The inferred bedrock faults are not considered to pose a seismic risk. (§2.4.2 Public Protection)	none noted

Table H-2 (continued)

Criteria	Potential Impacts for Onsite Locations	Specific to Proposed Location at Solar Ponds Area
Transportation	• Most of the waste targeted for the RWSF originates in the Industrial Area; haul distances would be shorter to sites inside the Industrial Area. (§2.4.3 RFETS Special Issues)	none noted
Short-term vs. Long-term	• The presence of significant clay fraction provides a relatively favorable environment for waste disposal, especially for strongly sorbed contaminants such as metals. (§2.4.2 Public Protection) • Several locations would require construction or upgrade of the onsite roads and site preparation, including building demolition, subsurface line removal, and rerouting access. (§2.4.3 RFETS Special Issues) • The timing of remedial activity implementation is more dependent on the WMF design and the permitting process than on the site selected. (§2.4.1 CAMU)	• Site preparation costs for the Solar Ponds area are at the upper end of the range for the various sites. (§2.4.3 RFETS Special Issues)
Cumulative Impacts	• Impacts from plutonium consolidation or residue stabilization activities are not a factor for siting the WMF. (§2.4.3 RFETS Special Issues)	• Solar Ponds would be an ideal candidate to support the Site Vision (i.e., Buffer Zone as open pace and Industrial Area as industrial/waste management) (§2.4.3 RFETS Special Issues)

Table H-3 Summary of Results: Evaluation of Environmental Impacts Facility Design Screen

Attributes	Design: Above-grade Storage Cell	Concrete Lined Cell with Bulk Placement	Concrete Lined Cell with Cargo Containers	Hardened Concrete Vault	Silo Design	Slab on Grade	Metal Buildings	Entombment	Pyramid Design	Waste Pile	No Action
Groundwater Protection	waste isolated from substrate and groundwater, run-off diverted to edges	provides reasonable assurances substrate and ground water protected, drainage around cap	see previous column; containers provide an additional barrier	drainage around cap	drainage around cap, includes a liner system	temporary facility, maintenance to avoid cracks	adequate for 30 years	numerous barriers	could require more maintenance to maintain protectiveness	adequate for 30 years	equivalent to better than landfill
Consistency	relatively larger footprint, supports Site Vision	relatively smaller footprint, supports Site Vision	relatively smaller footprint, supports Site Vision	footprint not as large as some options, some resource competition with TYP activities	small footprint, ties well to Site Vision	large footprint, short-term support to Site Vision	large footprint, short-term support to Site Vision	very large footprint, could negatively impact other Site activities	large footprint, timing could impact RFCA and TYP activities	does not support RFCA	consistent with RFCA

The facility design screen compared designs independent of location. This screen addresses technical issues and is not a primary source of environmental evaluation. Potential impacts are inherent in some of the criteria. The potential impacts to the environment cluster around a few attributes:

- Some designs offer more protection to the groundwater; the presence or absence of a liner and leachate collection system being an important design feature.
- Designs that are consistent with the Site Vision tend to reduce commitment of land. Location of the facility would also affect the consistency.

Table H-5 Summary of Results: Evaluation of Environmental Impacts Proposed Facility Design at Solar Ponds Location[1]

Criteria	Potential Impacts
Human Health §IV.10.1	Minimize existing risks due to long-term potential exposure to surficial soil, vadose zone soil, materials from D&D, and other remediation waste*(including all soils and materials noted in the list of wastes tentatively planned for placement in the RWSF)*. Short-term risks due to worker exposure to remediation waste that exceed PRGs during remediation. Potential adverse effects to workers as a result of encountering unknown utilities or uncharacterized areas of high contamination. Risks to workers associated with soil excavation, relocation, treatment processes and construction activities (e.g., increased fugitive dust generation, increased transportation requirements)
Environment Table IV.10-22	Temporary physical disruption of industrial area during construction; *approximately 10 acres for RWSF* affected by soil excavation, material staging, and construction activities Temporary physical disruption of borrow area used for clean fill material Increased local traffic requirements, increased dust generation during construction *and possibly during operation*, and increased potential for erosion due to changes in surface topography at *both the construction area* and borrow area Three small wetlands *may* require protection during construction, *depending on the details of the RWSF construction*. Wetlands banking *may be* considered as a mitigation measure *if the detailed design or in-field activities indicate impacts to the wetlands occur.* Mitigation measures may be required for the Prebles Meadow Jumping Mouse, which is being considered for listing as a federal endangered species. No floodplains will be affected
Ecological Risk §IV.10.2	*The area* has been characterized as a highly disturbed industrial area which can support only the most hardy species of plants and animals. The natural environment at and adjacent to *the RWSF site* has been significantly altered by construction and operation of the SEPs *(Solar Evaporation Ponds)* and other industrial facilities.... It is highly probable that these construction activities will interfere with any existing vegetation and animal use of the site.
Air Quality §IV.10.3	*Atmospheric dispersion calculations were prepared for the project proposed in the OU 4 Proposed IM/IRA-EA Decision Document. Those calculations demonstrate little risk due to exposure to site contaminants to remediation workers, on-site workers, or the public during construction. The original project included considerable excavation; the RWSF as currently envisioned will be constructed with less excavation and so should create less fugitive dust.* Potential increase in PM_{10} emissions at both *the construction area* and the borrow areas during construction
Ground Water Quality §IV.10.4	Potential effect on local hydrogeology by reducing percolation and changing topography in a potential recharge area *(Impacts specific to the design from the OU 4 DD have been omitted)*

[1]This table summarized the results of the evaluations at the Solar Ponds location. For further information, see indicated portion of Section IV.10 and Table IV.10-22 from the *OU 4 Proposed IM/IRA-EA Decision Document* (February, 1995). Some modifications from the OU 4 document are included in the RWSF; those modifications are noted by *italics*.

Table H-5 (continued)

Criteria	Potential Impacts
Surface Water Quality §IV.10.5	No surface water bodies exist within *the construction area* Consolidation of soil contamination *in the RWSF* will minimize or eliminate precipitation run-off *potentially contaminated by remediation wastes* *(Impacts specific to the design from the OU 4 DD have been omitted)*
Irretrievable/ Irreversible Commitment of Resources §IV.10.6	Clean fill from borrow areas, construction materials, and area underneath and adjacent to *the RWSF. No significant impact is expected in the selected site east of Solar Ponds since it is an IHSS and has already been impacted by previous and current industrial uses*
Natural Phenomenon Mitigation/ Mitigation Measures §IV.10.7	*The design proposed in the OU 4 DD and the final, capped form of the RWSF are similar. The OU 4 DD considered damage from excess snow loading, lightning strikes, tornado generated missile impacts, meteorite impacts, volcanism: these were found to be incredible or unlikely to cause damage. Glacial activity and reactivation of the alluvial fan would not effect the site within the timespan of 1,000 years used in the evaluation. Wind erosion and flooding would not damage the site. Earthquake analysis suggested the conditions under which a seismically induced slope failure could occur. Several faults are known to exist in the vicinity of Rocky Flats. None of the faults investigated to date have been found capable (movement within the last 1 million years displacing alluvial sediments). DOE will investigate the RWSF for capable faults before finalizing the design and proceeding to construction.*
Transportation §IV.10.8	Minor increase in traffic volume and patterns during construction activities; negligible impact on surrounding transportation infrastructure
Short-term vs. Long-term §IV.10.9	Short-term interruption of industrial area and borrow area required to minimize potential risks associated with exposure to site contamination Construction of *RWSF* will preclude unrestricted use of area underlying and adjacent to *the RWSF*
Cultural/ Archeological Resources §IV.10.10	No resources present
Cumulative Impacts §IV.10.11	Implementation of the preferred IM/IRA is consistent with the long-term mission of remediating the RFETS Implementing may interfere slightly with other activities in progress at the RFETS *(Impacts specific to the design from the OU 4 DD have been omitted)*
Direct/Indirect Effects Table IV.10-22	As described above Remediation of OU 4 sludges *and other remediation wastes to be placed in the RWSF* currently stored onsite will be expedited Short-term direct increase in remediation jobs; indirect job loss due to eliminating production functions at RFETS

Table H-4 ***Summary of Results: Evaluation of Environmental Impacts Proposed Facility Design at Solar Ponds Location***[1]

Criteria	Potential Impacts
Human Health §IV.10.1	Minimize existing risks due to long-term potential exposure to surficial soil, vadose zone soil, materials from D&D, and other remediation waste*(including all soils and materials noted in the list of wastes tentatively planned for placement in the RWSF)*. Short-term risks due to worker exposure to remediation waste that exceed PRGs during remediation. Potential adverse effects to workers as a result of encountering unknown utilities or uncharacterized areas of high contamination. Risks to workers associated with soil excavation, relocation, treatment processes and construction activities (e.g., increased fugitive dust generation, increased transportation requirements)
Environment Table IV.10-22	Temporary physical disruption of industrial area during construction; *approximately 10 acres for RWSF* affected by soil excavation, material staging, and construction activities Temporary physical disruption of borrow area used for clean fill material Increased local traffic requirements, increased dust generation during construction *and possibly during operation*, and increased potential for erosion due to changes in surface topography at *both the construction area* and borrow area Three small wetlands *may* require protection during construction, *depending on the details of the RWSF construction*. Wetlands banking *may be* considered as a mitigation measure *if the detailed design or in-field activities indicate impacts to the wetlands occur*. Mitigation measures may be required for the Prebles Meadow Jumping Mouse, which is being considered for listing as a federal endangered species. No floodplains will be affected
Ecological Risk §IV.10.2	*The area* has been characterized as a highly disturbed industrial area which can support only the most hardy species of plants and animals. The natural environment at and adjacent to *the RWSF site* has been significantly altered by construction and operation of the SEPs *(Solar Evaporation Ponds)* and other industrial facilities.... It is highly probable that these construction activities will interfere with any existing vegetation and animal use of the site.
Air Quality §IV.10.3	*Atmospheric dispersion calculations were prepared for the project proposed in the OU 4 Proposed IM/IRA-EA Decision Document. Those calculations demonstrate little risk due to exposure to site contaminants to remediation workers, on-site workers, or the public during construction. The original project included considerable excavation; the RWSF as currently envisioned will be constructed with less excavation and so should create less fugitive dust.* Potential increase in PM_{10} emissions at both *the construction area* and the borrow areas during construction
Ground Water Quality §IV.10.4	Potential effect on local hydrogeology by reducing percolation and changing topography in a potential recharge area *(Impacts specific to the design from the OU 4 DD have been omitted)*

[1]This table summarized the results of the evaluations at the Solar Ponds location. For further information, see indicated portion of Section IV.10 and Table IV.10-22 from the *OU 4 Proposed IM/IRA-EA Decision Document* (February, 1995). Some modifications from the OU 4 document are included in the RWSF; those modifications are noted by *italics*.

Table H-4 (continued)

Criteria	Potential Impacts
Surface Water Quality §IV.10.5	No surface water bodies exist within *the construction area* Consolidation of soil contamination *in the RWSF* will minimize or eliminate precipitation run-off *potentially contaminated by remediation wastes* *(Impacts specific to the design from the OU 4 DD have been omitted)*
Irretrievable/ Irreversible Commitment of Resources §IV.10.6	Clean fill from borrow areas, construction materials, and area underneath and adjacent to *the RWSF. No significant impact is expected in the selected site east of Solar Ponds since it is an IHSS and has already been impacted by previous and current industrial uses*
Natural Phenomenon Mitigation/ Mitigation Measures §IV.10.7	*The design proposed in the OU 4 DD and the final, capped form of the RWSF are similar. The OU 4 DD considered damage from excess snow loading, lightning strikes, tornado generated missile impacts, meteorite impacts, volcanism: these were found to be incredible or unlikely to cause damage. Glacial activity and reactivation of the alluvial fan would not effect the site within the timespan of 1,000 years used in the evaluation. Wind erosion and flooding would not damage the site. Earthquake analysis suggested the conditions under which a seismically induced slope failure could occur. Several faults are known to exist in the vicinity of Rocky Flats. None of the faults investigated to date have been found capable (movement within the last 1 million years displacing alluvial sediments). DOE will investigate the RWSF for capable faults before finalizing the design and proceeding to construction.*
Transportation §IV.10.8	Minor increase in traffic volume and patterns during construction activities; negligible impact on surrounding transportation infrastructure
Short-term vs. Long-term §IV.10.9	Short-term interruption of industrial area and borrow area required to minimize potential risks associated with exposure to site contamination Construction of *RWSF* will preclude unrestricted use of area underlying and adjacent to *the RWSF*
Cultural/ Archeological Resources §IV.10.10	No resources present
Cumulative Impacts §IV.10.11	Implementation of the preferred IM/IRA is consistent with the long-term mission of remediating the RFETS Implementing may interfere slightly with other activities in progress at the RFETS *(Impacts specific to the design from the OU 4 DD have been omitted)*
Direct/Indirect Effects Table IV.10-22	As described above Remediation of OU 4 sludges *and other remediation wastes to be placed in the RWSF* currently stored onsite will be expedited Short-term direct increase in remediation jobs; indirect job loss due to eliminating production functions at RFETS

NOTICE:

"BEST AVAILABLE COPY"

PORTIONS OF THE FOLLOWING DOCUMENT ARE ILLEGIBLE

The Administrative Record Staff

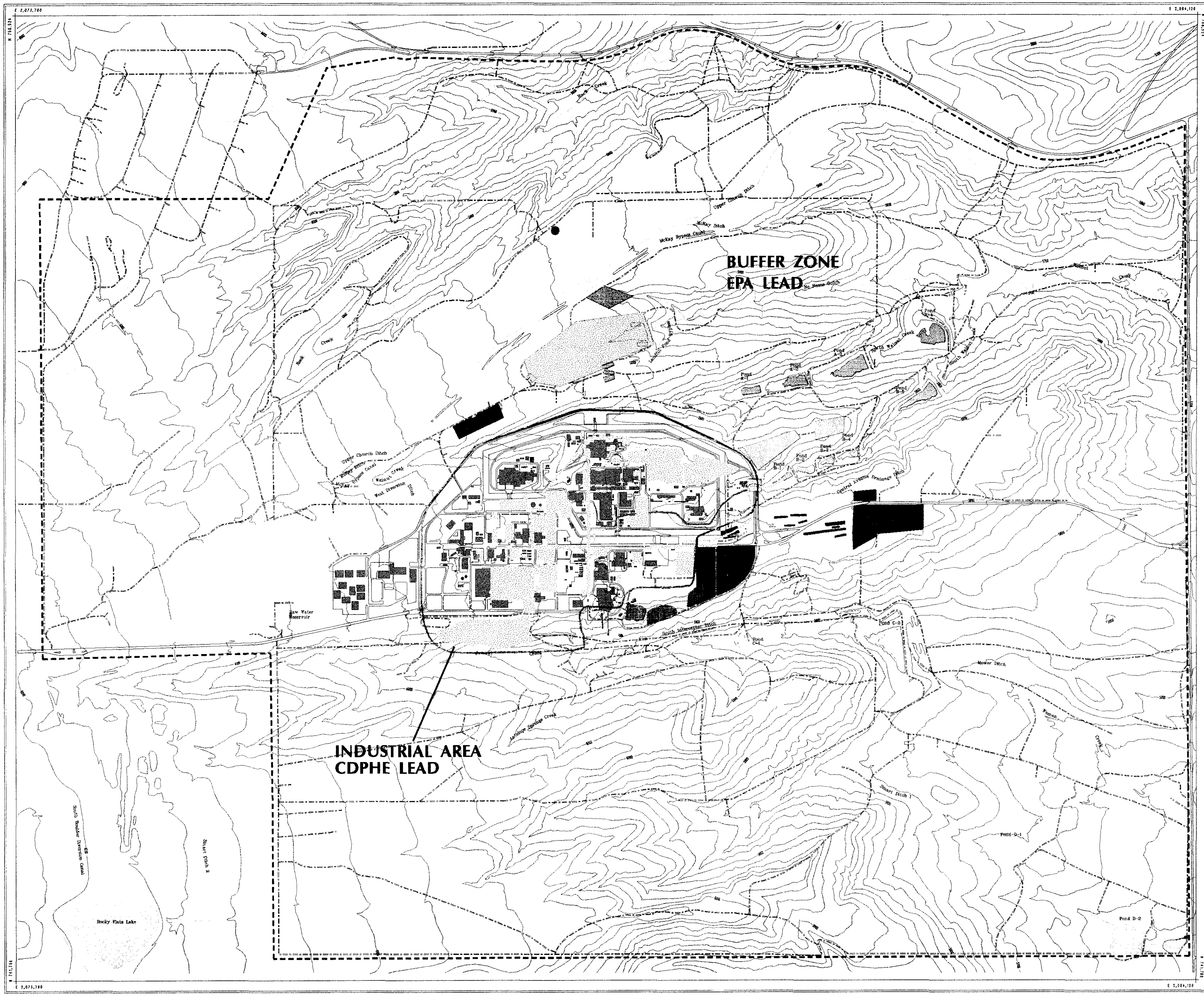

Figure 1-2
Proposed Consolidated Operable Units

Conceptual Strategy Purposes for Discussion Only

See paragraph 67 of RFCA

EXPLANATION

Note: OU3 not shown

- Industrial Area OU
- Buffer Zone OU
- Operable Unit 1
- Operable Unit 5
- Operable Unit 6
- Operable Unit 7
- Operable Unit 11 Closed through CAD/ROD Process
- Operable Unit 15 Closed through CAD/ROD Process
- Operable Unit 16 Closed through CAD/ROD Process
- Individual Hazardous Substance Sites (IHSS)

Standard Map Features

- Buildings or other structures
- Lakes and ponds
- Streams, ditches, or other drainage features
- Fences
- Contours (20' Intervals)
- Rocky Flats boundary
- Paved roads
- Dirt roads

DATA SOURCE:
Buildings, roads, and fences provided by Facilities Engr., EG&G Rocky Flats, Inc. - 1991.
Hydrology provided by USGS - (date unknown)
Proposed Consolidated OU's data provided by Annette Primrose of RMRS/SA - 9-1995.

Scale = 1 : 19910
1 inch represents approximately 1659 feet

500 0 1000 2000ft

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

U.S. Department of Energy
Rocky Flats Environmental Technology Site

MAP ID: x8682 May 20, 1997

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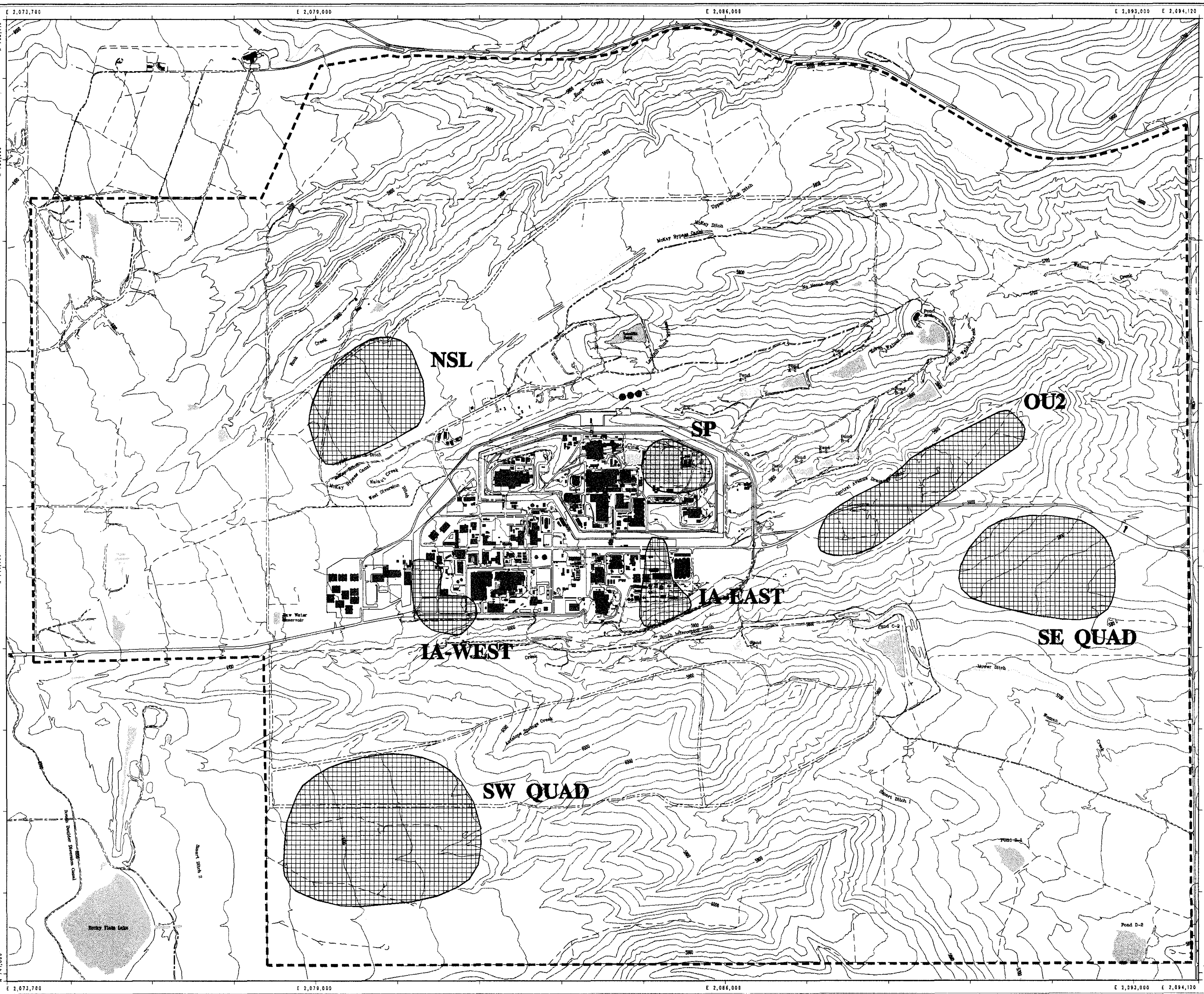

Figure 5-2
Location Map

EXPLANATION

Potential RWSF Sites

NSL - New Sanitary Landfill
ESF - East Spray Fields
SP - Solar Ponds plus IHSS 165 and 176

SW QUAD - Southwest Quadrant
SE QUAD - Southeast Quadrant
IA WEST - Industrial Area West
IA EAST - Industrial Area East

Standard Map Features

- Buildings or other structures
- Lakes and ponds
- Streams, ditches, or other drainage features
- Fences
- Contours (20' intervals)
- Rocky Flats boundary
- Paved roads
- Dirt Roads
- Trails

DATA SOURCE: Buildings, roads, and fences provided by Facilities Engr., EG&G Rocky Flats, Inc. - 1991. Hydrology provided by USGS - (date unknown)

Scale = 1 : 19840
1 inch represents approximately 1637 feet

500 0 1000 2000ft

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

U.S. Department of Energy
Rocky Flats Environmental Technology Site

Prepared by:

RMRS Rocky Mountain Remediation Services, L.L.C.
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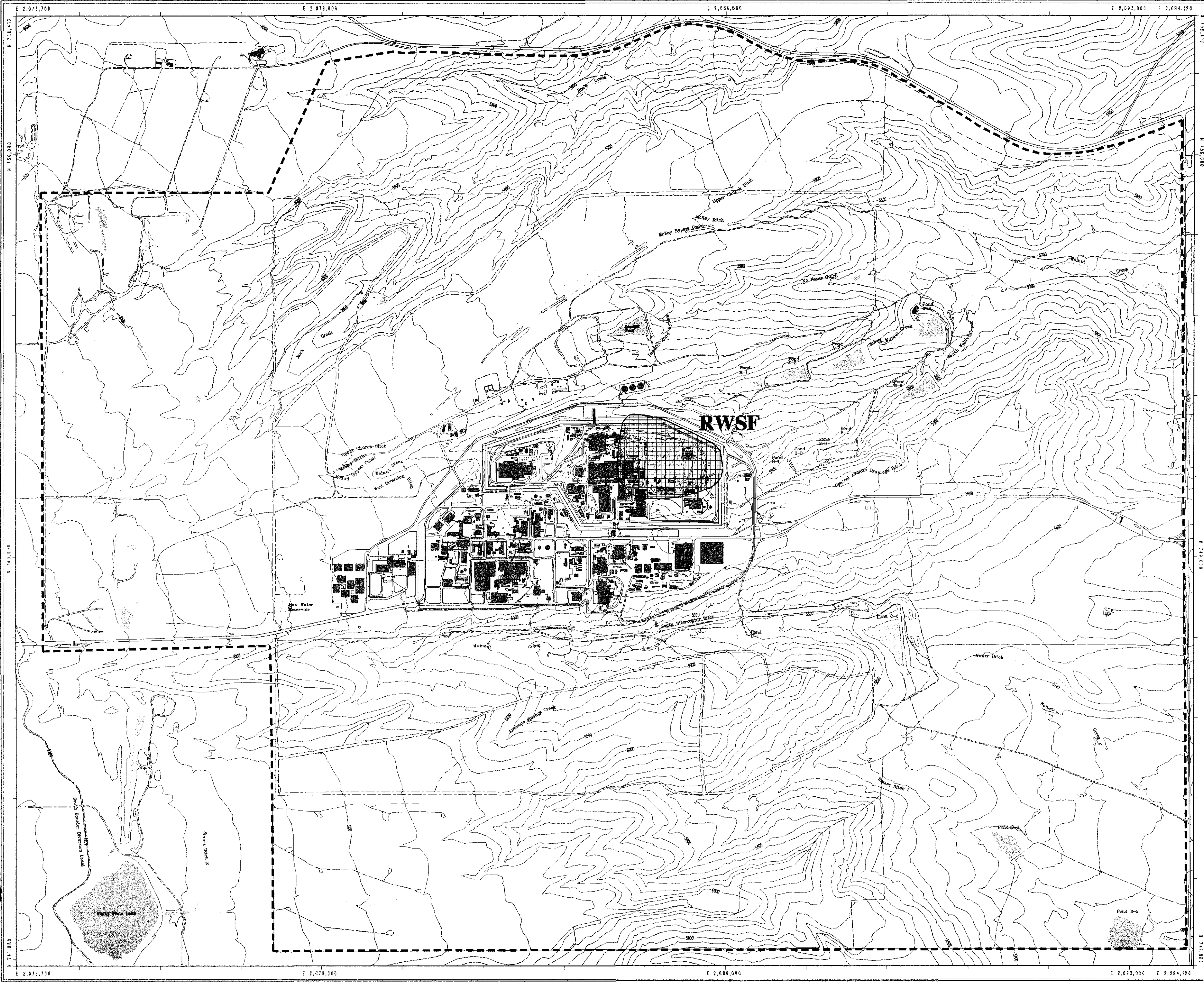
Rocky Flats Environmental Technology Site
P.O. Box 464
Golden, CO 80402-0464

MAP ID: 97-0014

May 20, 1997



Selected Figure 7-1
Site Location Map

EXPLANATION

Potential RWSF Sites

Standard Map Features

Buildings or other structures

Lakes and ponds

Streams, ditches, or other drainage features

Fences

Contours (20' Intervals)

Rocky Flats boundary

Paved roads

Dirt Roads

Trails

DATA SOURCE:
Buildings, roads, and fences provided by Facilities Engr., EG&G Rocky Flats, Inc. - 1991.
Hydrology provided by USGS - (date unknown)

Scale = 1 : 19640
1 inch represents approximately 1637 feet

500 0 1000 2000ft

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

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Golden, CO 80402-0464

MAP ID: 97-0015

May 20, 1997

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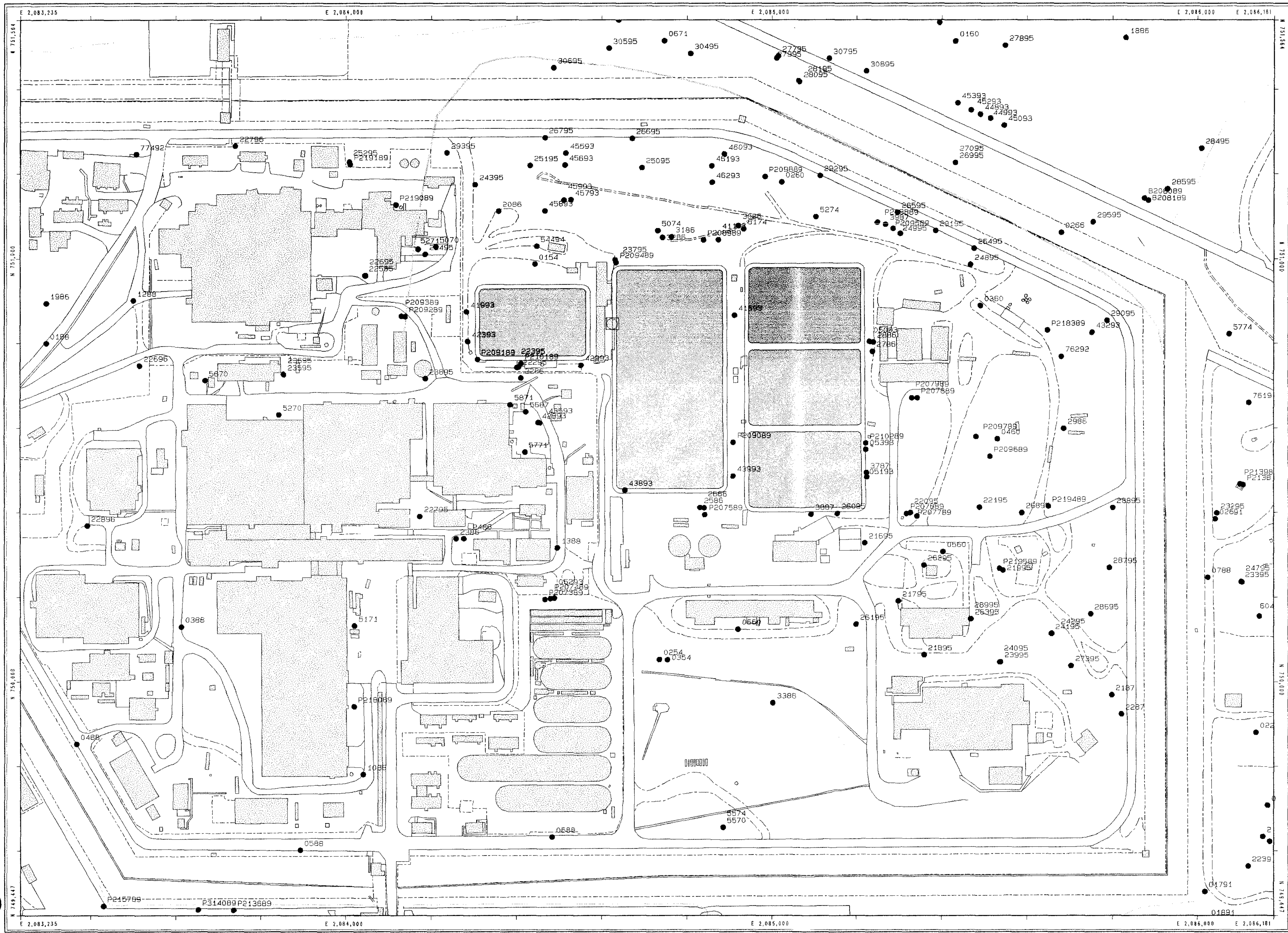

Site Location Map

EXPLANATION

Potential CAMU Designation Area

Buildings & other structures

Standard Map Features

Lakes and ponds

Streams, ditches, or other drainage features

Fences

Paved roads

Dirt roads

DATA SOURCE:
Buildings, roads, and fences provided by Facilities Engr., EG&G Rocky Flats, Inc. - 1991.
Hydrology provided by USGS - (date unknown)

Scale = 1 : 2870
1 inch represents approximately 239 feet

50 0 100 200ft

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

U.S. Department of Energy
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